1996

The Effects of Analytic Reading Skills on Sixth Graders' Ability to Solve Mathematical Story Problems.

Linda Hale Eilers
Louisiana State University and Agricultural & Mechanical College

THE EFFECTS OF ANALYTIC READING SKILLS ON SIXTH GRADERS' ABILITY TO SOLVE MATHEMATICAL STORY PROBLEMS

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Curriculum and Instruction

by

Linda Hale Eilers
B. S. E., University of Arkansas at Little Rock, 1973
M. Ed., University of Arkansas at Little Rock, 1984
May, 1996

UMI Number: 9637770

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

Acknowledgements

Dr. Earl H. Cheek, Jr. has provided superb leadership as chair and major professor during my doctoral studies. I greatly appreciate his assistance, along with that of Dean F. Neil Mathews, Dr. Gary Rice, Dr. Janice Stuhlmann, and Dean Cargill. I wish to thank Dr. Virginia Eddleman for her friendship and continual encouragement and Dr. Bob Cage for his invaluable expertise, patience, and assistance.

I am most grateful to the Monroe City School System (Dr. George Cannon, Superintendent and Mrs. Mary Guinn, Assistant Superintendent) and the staff (Mrs. JoAnn Pee, Principal) and students at J.S. Clark Magnet School who assisted with and participated in this study. To Mrs. Luanne Saam, sixth-grade teacher, gratitude is given for enabling me to conduct this study.

Finally, my love and genuine gratitude go to my husband, Walt, for his encouragement and support during this endeavor. To my father and my mother (who watches from above) I extend my love and thankfulness for inspiring and challenging me. I am truly grateful to my brother, other family members, and friends for their interest throughout my doctoral pursuit.

Table of Contents

List of Tables

Abstract

The purpose of the present study was to determine the effects of two levels of instructional treatment on sixth graders' ability to solve mathematical story problems. The two levels of instructional treatment were instruction in the use of graphic organizers in conjunction with specific analytic reading skills and instruction in specific analytic reading instruction alone. These were compared to the absence of either treatment. The steady decline in students' scores on measures of ability to read and solve story problems over the past decade prompted research in three sixth-grade public school classes in northeast Louisiana.

The study employed an experimental/control, three-group design. Analysis of covariance (ANCOVA) was used to adjust for any intact group mean differences. The Tukey (HSD) ad hoc comparison was applied to those results. The independent variable was instructional treatment. The Story Problems Test, an instrument developed and pilot-tested by the investigator, was the criterion measure for the study. The covariate was the achievement scores derived from the preadministration of the instrument and the dependent variable was the postadministration achievement scores that measured the effects of the treatments.

Instruction in the use of graphic organizers in conjunction with analytic reading skills resulted in significantly higher ($p < .05$) adjusted post-mean scores when compared to the group that received no treatment. There was no significant difference between the adjusted post-mean scores of students instructed in utilization of graphic organizers and analytic reading skills when compared to those instructed in analytic reading skills alone. A significant difference ($p < .05$) was found between those students instructed in analytic reading skills as compared to those who received no treatment. There was no significant difference in the relationship between specific reading ability and problem solving ability and between computation and problem solving ability as measured by the subtests of the Story Problems Test. The findings of this study support the notion that instruction in specific analytic reading skills (with or without graphic organizers) improves students' ability to solve story problems.

Chapter 1

Introduction

Cartoonist Gary Larson once published a cartoon entitled "Hell's Library." The cartoon depicted a bewildered soul perusing library shelves while flames licked his feet. The books on the shelves revealed such titles as Story Problems, Big Book of Story Problems, More Story Problems, Even More Story Problems, Story Problems Galore, and Story Problems Galore and More. Although quite amusing, unfortunately, this is a common reaction to story problems. Most of us recall elementary school experiences involving story problems with feelings of anxiety, frustration, and disdain.

Experts from a variety of disciplines have speculated as to the reason for these feelings of trepidation. Difficulties solving story problems are attributed to different causes. Many believe that the inability to compute mathematically is at the root of these difficulties. Others feel that inadequate analytic reading skills pose the major obstacles.

Krulik (1980) argues that students need good general reading skills to comprehend mathematics. The technical vocabulary of mathematics and the unique text of story problems require specialized reading skills. Many feel that the reading skills taught during reading class automatically transfer to the mathematics classroom, while others challenge this assumption (MacGregor, 1990). Singer & Donlan (1989) suggest that elementary teachers are successful in teaching most students to read, but do not give them the necessary instruction for reading effectively in all content areas. These experts further propose that there should be special instruction during mathematics class to develop the specific skills necessary for reading specialized text.

Purpose of the Study

The purpose of the present study was to investigate through quantitative methodologies the effects of instruction in (a) specific analytic reading skills in conjunction with a graphic organizer and (b) specific analytic reading skills taught in a mathematics context on sixth graders' ability to solve mathematical story problems. The intent was to ascertain the degree to which analytic reading skills and graphic organizers influenced the ability to successfully solve mathematical story problems. The study determined the extent to which specific reading instruction in a mathematics context, administered in addition to regular reading and mathematics instruction, affected sixth graders' ability to solve story problems. The basic preferred hypothesis in the study was that sixth graders receiving instruction in specific analytic reading skills, with or without graphic organizers, would show greater achievement in the accurate solution of story problems than sixth graders who received no special instruction.

The hypothesis was tested by comparing three groups of sixth grade students at an elementary mathematics magnet school in Monroe, Louisiana. The intact classes were randomly assigned to one of two treatment groups and the control group. Students in the two treatment groups received ten hours of special instruction delivered by the investigator over a four month period. The special instruction was in addition to regular reading and mathematics instruction. A pretest was administered to all three groups to establish baseline data and a posttest was administered to all three groups following the delivery of special instruction. Analysis of covariance statistical techniques tested the data to determine the effects of the special instruction.

Background of the Problem

Since the late 1970s the focus of mathematics education has been problem solving. The National Council of Teachers of Mathematics has published numerous documents (1980; 1989; 1991) stressing the importance of problem solving. Even though problem solving in general and story problems in particular have been the central focus of literature on mathematics curriculum for the past decade, solving story problems remains the most difficult aspect of mathematics for many students. Despite all the attention to this area, tests like the National Assessment of Educational Progress (NAEP) indicate that most children have difficulty solving story problems which require some analysis or thinking (Kouba, Brown, Carpenter, Lindquist, Silver & Swafford, 1988). Results from the 1992 NAEP indicate that the same children who solve computational problems well, experience difficulty applying these computational skills to problem solving situations (Mullis, Dossey, Owen & Phillips, 1993).

Although elementary teachers succeed in teaching most students to read, they do not prepare them effectively for learning from content-specific text (Singer and Donlan, 1989). Children are more likely to have language-related difficulties in the mathematics classroom than they experience anywhere else. Most teachers are unaware of the level of reading skills necessary for comprehending technical text. Mathematics teachers can no longer assume that their pupils have acquired sufficient syntactic awareness and analytic reading skills to handle mathematical text. Learning how to read mathematical text needs to be part of the mathematics curriculum (MacGregor, 1990).

Significance of the Study

The present study has the potential to identify strategies for improving children's ability to comprehend technical text. Knowledge of the difficulties children experience when processing mathematical language and recognition of the specialized reading skills necessary to comprehend mathematical text may lessen the gap between the ability to solve straight computation and the ability to solve story problems. Special instruction for the study addressed the following areas:

1. Graphic organization of the text of story problems. The lessons addressed spatial arrangement of key concepts to comprehend the text of story problems.

2. Analytic reading skills necessary to evaluate story problems. The lessons presented techniques for evaluating the text of story problems to determine sufficient, insufficient, relevant, and irrelevant information.

3. Literal and inferential comprehension of content specific text. The lessons further focused on strategies for identifying the main idea and discovering relationships.

The present study investigated the interaction of reading skills and problem solving abilities in three sixth grade classes at a mathematics magnet school in Monroe, Louisiana. An underlying assumption was that the abilities required for reading the content specific text of story problems differ from the abilities required for reading narrative text. The findings of the present study were determined through the analysis of test data collected over a four-month period during the 1995-1996 school year.

The study examined the effect of specific analytic reading skills and the use of graphic organizers taught in a mathematics context on sixth graders' ability to solve mathematical story problems.

Definition of Terms

Throughout the discussion of the present study, many terms identified with the instruction of elementary students in the areas of reading and mathematics are used. An understanding of the following terms facilitates the reading of this dissertation:

Analytic reading skills--The ability to read critically to distinguish between sufficient, insufficient, relevant, and irrelevant information.

Control Group--The group that received no treatment effect. No special instruction was delivered to this group. These students met in a study hall setting and completed homework, library research, or read.

Critical thinking--Logical thought process characteristic of careful analysis as with the scientific method (Harris & Hodges, 1995).

Experimental Group 1--The group that received lessons (in addition to regular classroom instruction) of special instruction by the investigator in specific analytic reading skills and the use of graphic organizers while solving story problems.

Experimental Group 2--The group that received instruction (in addition to regular classroom instruction) in specific analytic reading skills delivered by the investigator. Involved were those separate reading abilities used in processing content specific text, such as reading for main idea, reading for details, reading for sequence of ideas, and making inferences.

Graphic Organizers--The spatial organization of text to depict relationships through any type of visual array. They are used to facilitate understanding of expository text through graphically arranged key concepts (Berkowitz, 1989; Guri-Rozenbilt, 1989; Simmons, Griffin, & Kameenui, 1988, (e.g., concept map, semantic map, semantic organizer, structured overview, Venn diagram, web). An example of the graphic organizer used in the present study appears in Appendix E.

Story problem--A problem statement which includes a question that must be answered through critical thinking and mathematical computation.

Successful problem solving--The ability to identify the problem, develop a plan, execute the plan, and arrive at a correct response.

Limitations of the Study

Experimental research studies of this nature are typically delimited in some aspects. The present study was delimited in the following ways:

The investigator restricted the study to three sixth-grade classrooms in a mathematics, science, computer magnet school in Monroe, Louisiana. Two classrooms received instruction as the treatment groups, and the third classroom received no instruction as the control group. These three classrooms in this magnet school may not be similar in all respects and may not be representative of other schools in the system, state, or country. The study involved subjects in three intact classrooms rather than randomly-selected subjects.

The study was confined to a four-month treatment period which took place in the fall semester. It is possible that this time frame did not allow for measurable improvement to occur from all treatments. Had the study been extended for a longer period of time, it is conceivable that greater growth would have occurred.

The investigator taught both treatment groups. Instruction was delivered in those specific analytic reading skills identified by the investigator as critical to the success of solving story problems. Those skills may not be the only or most essential ones involved in the solution of story problems.

A range of reading skills identified as critical by the investigator was presented to both treatment groups. It is difficult to ascertain which of these skills in particular may have affected the students' ability to solve story problems. Discrete skills were not isolated.

Instruction in the utilization of graphic organizers was presented to one group in addition to the instruction in analytic reading skills. The thirty-minute class sessions restricted the in-depth use of the organizers in the solution of all story problems presented. Time constraints prohibited this treatment group (Group 1) from solving as many story problems as the group which received instruction in analytic reading skills alone (Group 2). Since the criterion instrument measured the effects of graphic organizers rather than text organization directly, it is possible that the full effects of this treatment were not measured.

The specific instruction in the utilization of graphic organizers in conjunction with instruction in specific analytic reading skills and instruction in specific analytic reading skills alone were delivered in addition to regular classroom instruction in reading and mathematics. It is possible that additional instruction and practice in story problems solution caused the improvement.

The investigator delivered the specific instruction in the utilization of graphic organizers with instruction in specific analytic reading skills, and instruction in specific analytic reading skills alone to the two treatment groups. The control group met with the regular classroom teacher in a study-hall type setting. It is possible that the novelty or innovative nature of the treatment, compared with the routine of the study hall environment, may have been as influential as the actual treatment.

Because permission to participate in the study had to be granted by both student and parent, the students in the two treatment groups and the control group knew they were part of an experimental study. This knowledge may have influenced the behavior of the subjects in all three groups.

Since a paper and pencil test was the criterion measure for the study, it has not been determined to what extent test anxiety may have influenced the results. Apprehension generated by participation in the experiment may have affected the subjects' performance.

Although every effort was made to control for these variables, they may or may not have confounded or accounted for the effects of the treatment in the present study.

Organization of the Chapters

The remaining chapters are organized in the following manner. The second chapter provides a review of pertinent literature and research. There are four major sections presented in the following order. The first section points out the disparity between children's ability to perform mathematical computations and their ability to solve story problems. The next section discusses factors which are influential for successful solution of story problems. The third section presents evidence which indicates a relationship between general reading ability and successful problem solving. The final section suggests that specific reading strategies may increase students' ability to solve story problems. This section looks at the use of graphic organizers and how they are used to organize technical text as well as in the solution of story problems.

The third chapter presents the methodology of the study. This chapter describes the research design, setting, subjects, experimental conditions, major and minor hypotheses, as well as materials and procedures used in the study. Chapter four provides analyses of data for both experimental treatments and the control group. The findings of the study, including results of testing of major and minor hypotheses, are delineated through narrative text. Tables and figures present statistical analyses. Rationale for selection of particular statistical procedures utilized for the study is discussed. The fifth chapter provides a summary of the results, conclusions and discussion, as well as implications and recommendations for practice and future research.

Chapter 2

Review of Pertinent Literature and Related Research

This chapter presents pertinent literature and research that is relevant to the topic of this dissertation. The first section points out the disparity between children's ability to perform mathematical computations and their ability to solve story problems. The next section discusses factors which affect the solution of story problems. The third section presents evidence which indicates a relationship exists between general reading ability and successful problem solving. The final section suggests specific reading strategies may enhance students' ability to solve story problems.

Disparity between Computational and Problem Solving Skills

Since 1980 the National Council of Teachers of Mathematics has published official documents which recommend problem solving as a significant focus of school mathematics. Numerous articles, research studies, and books have echoed this recommendation. The majority of this literature focused on story problems. The result of all this attention to problem solving should have been an increase in student achievement. Standardized tests, however, still indicate a deficiency in children's ability to solve story problems which require more than simple addition and subtraction (Kouba, et al., 1988).

Beginning in the late 1970s, a key focus of the leaders in the field of mathematics education became problem solving. In 1980 the National Council of Teachers of Mathematics published a position paper, An Agenda for Action: Recommendations for School Mathematics of the 1980s (NCTM, 1980) which recommended problem solving as the number one focus of school mathematics. The Curriculum and Evaluation Standards for School Mathematics, another document from the National Council of Teachers of Mathematics (1989), listed problem solving as the first standard for mathematics in grades K-4 and 5-8. More recently, the National Council of Teachers of Mathematics published a companion document to the standards, Professional Standards for Teaching Mathematics (1991), which also stressed the importance of problem solving. During this time there have been many articles, papers, conferences, workshops, and teachers' lounge conversations devoted to the challenging topic of problem solving.

Even though problem solving has been a major focus of literature on mathematics curriculum for the past decade, it remains the most difficult aspect of mathematics for many students (Kroll & Miller, 1993). Results from the 1992 National Assessment of Educational Progress (Mullis, et al., 1993) indicated that the same American students who performed computational skills fairly well experienced difficulty applying these skills to problem solving situations.

According to Gleason, Silbert, and Carnine (1990) the first National Assessment of Educational Progress included five story problems. Four involved each of the four basic operations and one required two operations. Results of this test showed that only 25% of the fourth graders and 62% of the eighth graders were able to solve all five of the story problems correctly. These authors further reported that five years later when the NAEP was repeated, there was an 18% decline in accuracy for story problems which required multiplication and a 12% drop in story problems which required simple division.

Data from the third National Assessment of Educational Progress revealed that although "almost 70% of the 13-year-olds correctly multiplied 2/3 X 2/5, fewer than 20% could solve a verbal problem similar to the following: 'Jane lives 2/3 mile from school. When she has walked 2/5 of the way, how far has she walked?'" (Carpenter, Corbitt, Kepner, Lindquist, & Reys 1980, p. 10). There appears to be agreement within the literature that students' difficulty in solving story problems is reflected in the results of the National Assessment of Educational Progress reports over the past several years.

Other investigations substantiate these reports. The results of a study conducted by O'Brien and Casey (1983) indicated that 33% of a group of sixth graders were unable to write a story problem that correctly fit the number sentence 6 X 3 = 18. In this study sixth graders were given number sentences involving all basic operations and asked to write story problems that required those numbers and operations. The results of another study (Sowder, 1988) revealed that while a group of sixth graders were competent in computing with whole numbers, and successful in solving single-step problems, they reverted to mindless strategies when attempting to solve more challenging problems. Rather than choosing numbers and arithmetic operations according to the meaning of a problem, it appeared that they tried all basic operations (addition, subtraction, multiplication, division) on various numbers in the problem, and then chose an answer.

Similar findings were reported by Erlwanger (1974), who interviewed students about the strategies they employed in solving story problems. One student explained that his technique for solving story problems was to first examine the numbers for size. If there were two "big" numbers, he subtracted. If one number was large and the other was small, he divided. And if that did not "come out even," he multiplied.

Corwin and Price (1995) cautioned that the majority of American students are not learning to perform mathematical operations in a flexible manner. The investigators referred to National Assessment of Educational Progress results which indicated that despite some increase in mathematics achievement since 1976, American students still lacked higher-order mathematics skills. These authors blamed the rigid adherence to rote teaching of mathematical procedures for students' inability to apply skills or go beyond classroom routines. They implored our schools to produce mathematically literate graduates who could assess situations, determine what is being asked for, and have enough number sense to know whether the results are reasonable.

In summary, national test results reflect a slight increase in lower level skills of mathematical abilities, yet a steady decline in higher level skills such as problem solving. The reform movement in mathematics education initiated by the National Council of Teachers of Mathematics has not generated the anticipated growth in students' ability to apply computational skills to solving story problems. Concerns over the decline in students' ability to successfully solve story problems spawned research aimed at identifying those factors which cause difficulty or influence success. The next section examines some of those factors.

Factors Which Influence Student Performance

It is well documented that students experience considerable difficulty when attempting to solve story problems (Carpenter, et al., 1980; Kouba, et al., 1988; Kroll & Miller, 1993; O'Brien & Casey, 1983; Sowder, 1988). A review of the literature reveals numerous variables that are identified as factors which may contribute to students' difficulty with story problems. There appears to be a consensus that literacy plays an important role.

Some of the specific literacy factors that have been examined are (a) difficulty of the text (Laborde 1991; Muth, 1993), (b) use of the textbook (Muth 1993; Ratekin, Simpson, Alvermann, & Dishner, 1985; Romberg & Carpenter, 1986; Singer & Donlan, 1989), (c) syntactic and semantic organization (Siegel, Borasi & Smith, 1989); Moyer, Moyer, Sowder, & Threadgill-Sowder, 1984; Moyer, Sowder, Threadgill-Sowder, & Moyer, 1984; Thomas, 1988), (d) vocabulary (McNinch, 1982; Murray, 1993; Newman, 1977; Skrypa, 1979), and (e) extraneous information (Blohm & Wiebe, 1980; Muth, 1984; Singer & Donlan, 1989).

Difficulty of the Text

Several reading experts have looked closely at mathematical text. Muth (1993) described the mathematical text of story problems as a hybrid of narrative and expository prose. Braselton and Decker (1994) stated that the complexity of mathematical text made it the most challenging of all content area material to read. They proposed the propensity for more concepts per word, per sentence, and per paragraph, as well as the intermingling of words, numerals, letters, symbols, and graphics in the text as an explanation for its complexity. Laborde (1991) described mathematical text as highly dense. He asserted that the high density of information in story problems made them more complicated. This density is due to the fact that the text relates problem statements which attempt to disclose all information necessary for solving a problem in the most concise form. Laborde noted that such a format increased the likelihood of students overlooking important details when solving story problems.

According to these experts mathematical text is unique and often problematic. Therefore, the technical text of story problems should be a factor when investigators consider children's difficulty with them.

Use of the Textbook

A study conducted by Ratekin, Simpson, Alvermann, and Dishner (1985) indicated that mathematics teachers relied on the textbook in presenting content more than teachers do in any other content area. Another study commissioned by the National

Advisory Committee on Mathematical Education in 1975 (Romberg & Carpenter, 1986) reported that in the average elementary mathematics classroom, teachers relied heavily on a single text for whole-class instruction. According to Singer and Donlan (1989), regardless of their reading ability, most students work from the same mathematics text without benefit of individual instruction. In contrast, during reading class efforts are made to individualize reading instruction by matching the text to the reading ability of the students.

There is evidence that reading plays a significant role in mathematics and that mathematics teachers depend almost exclusively on the textbook. According to one study (Muth, 1993) it appeared that mathematics teachers were uncertain about the role reading played in mathematics learning and their role in teaching students to read mathematics. In 1993 Muth conducted a descriptive study to investigate mathematics teachers' beliefs about the role reading played in mathematics learning. A questionnaire was distributed to 114 middle-grade mathematics teachers in 14 middle schools in a southeastern state. The results of the study revealed that teachers perceived comprehension as the primary source of their students' difficulty with solving story problems; yet they were undecided about their role as mathematics teachers in dealing with this issue. To further complicate matters, these teachers stated that content reading methods courses typically neglected mathematics and tended to focus on science and social science text. The teachers surveyed indicated that they did not view content reading instruction to be beneficial to mathematics teachers.

Graebell and Anderson (1992) claimed that even if teachers recognize the importance of reading skills in solving story problems, many assume their students automatically transfer the skills used in reading story selections to reading word problems and frequently overlook the role that reading comprehension plays in mathematical problem solving. The investigators further cited the compartmentalization of the elementary curriculum as an obstacle to exploration of the relationships of thinking processes and pedagogical principles that exist between reading and mathematics.

Syntactic and Semantic Organization

The syntactic and semantic organization of story problems is a frequently studied stumbling block. According to Siegel, Borasi, and Smith (1989) the syntactic and semantic organization of story problems has been a major concern. Considering these concerns, researchers (Moyer, Moyer, Sowder, & Threadgill-Sowder, 1984; Moyer, Sowder, Threadgill-Sowder, & Moyer, 1984) examined the effects of syntactic organization. These investigators compared three different syntactic organizations of story problems to determine students' ability to select the appropriate operation for successful solution. The first study presented story problems in both telegraphic (characterized by short phrases with all noncritical elements removed) and verbal formats. The ability of upper elementary students to extract information was measured. Results indicated that the verbal format was somewhat easier for students. The second study compared telegraphic, verbal, and drawn formats. The drawn format consisted of a labeled drawing in the story problem. The findings favored the drawn format. The students' performances improved dramatically when presented with full problem statements accompanied by pictures. The results showed no difference between the effects of telegraphic and verbal formats on the students' ability to choose the correct operation for solution of the story problems.

Thomas (1988) posited that readers need special semantic rules for interpreting mathematical story problems. He suggested that it is the complex nature of the text of story problems rather than the mathematical operations that frustrate and hinder students. According to Thomas, readers need more than ordinary linguistic knowledge and mathematical skill. They must possess a specialized semantic knowledge about the way story problem statements are to be read and interpreted.

Vocabulary

Newman (1977) analyzed the errors on sixth graders' written mathematical work. After examining 3,000 errors made by 124 low achieving sixth graders, she reported that 13% of the errors were a result of the students' inability to say the words indicating a lack of comprehension. This percentage approximated the 14% error rate caused by the students' inability to comprehend the question. Newman further noted that 8% of the errors made by the sixth graders were due to the lack of knowledge of the meaning of key vocabulary terms. The results of Newman's study gave credence to the argument that the ability to decode words affects mathematical performance. Students must recognize basic sight words to cope with the text of story problems.

Other research regarding the effects of specific skills instruction in mathematics vocabulary has given credence to the practice of teaching reading skills in mathematics classes. McNinch (1982) found that even limited direct instruction in vocabulary terms resulted in dramatic gains in students' comprehension. Using gain scores from the Standard Diagnostic Test in mathematics vocabulary and problem solving as the dependent variables, this investigator noted that after delivery of small amounts of planned vocabulary instruction, test scores increased.

These findings supported earlier research done by Skrypa (1979). Results of her study suggested that teaching mathematics vocabulary led to improved scores on the Standard Diagnostic Test, indicating a gain in not only vocabulary but problem solving skills as well.

After analyzing the vocabulary of mathematical text, Murray (1993) agreed that it was more difficult due to the technical vocabulary which overlapped what he called "ordinary English." He also suggested that the smaller number of context clues in a passage may have added confusion. These findings strengthened the argument that several strong links among reading skills, knowledge of math vocabulary, and problem solving ability exist.

Extraneous Information

In 1984 Muth isolated the factor of extraneous information in story problems to determine what difficulties sixth graders experienced. She found that extraneous information reduced accuracy and increased test-taking times. About 13% of the variance in correct answers and 8% of the variance in test-taking times were attributed to the presence of extraneous information in the story problems. These results supported the 1980 findings of

Blohm and Wiebe which indicated that the inclusion of extraneous information greatly interfered with students' problem solving success.

Reading experts Singer and Donlan (1989) corroborated these findings. These authors noted several sources for difficulties that students experience when solving story problems. One source was the students' inability to comprehend technical vocabulary and mathematical terms associated with a formula. For example, a story problem might interchange the words "rate" and "speed." They cautioned against the erroneous assumption that students understand the technical vocabulary and automatically recognize its synonyms. Another obstacle that students encounter is difficulty manipulating syntax. Frequently the information presented in the story problem is in an order different from the order of the formula or operation with which they are familiar. Students may know the formula D = rt (Distance is equal to rate multiplied by time), but, if the story problem gives the distance and time variables and asks for the rate, they may become confused. Many students are unable to transform syntax by changing the order of variables in story problems. Singer and Donlan also noted that the inclusion of extraneous information caused difficulty for many students. They proposed that successful problem solvers are able to identify terms, symbols, and their synonyms. They asserted that proficient students are also able to manipulate syntax and distinguish between relevant and irrelevant information.

Other Factors

Other factors noted as possible contributors in students' ability to solve story problems are critical thinking, practice, and cue words.

Critical Thinking. Szetela and Nicol (1992) argued that in order for students to logically interpret story problems, they must confront a novel situation by formulating connections between given facts, identifying the goal, and exploring possible strategies for attaining that goal. They believe that successful problem solving requires considerable thinking and, of equal importance, the ability to communicate that thinking. Romberg and Carpenter (1986) reported that differences between successful and unsuccessful problem solvers are attributed to fundamental differences in the way they monitor and control their thinking. Successful problem solvers try to structure information as they learn it; unsuccessful problem solvers do not (Krutetski, 1976; Silver, 1979).

According to Garofalo and Lester (1985), success in problem solving depends upon metacognitive processes. They outlined the following seven-step sequence of actions for successful problem solving:

1. Get a proper perspective of the problem situation.
2. Contemplate all possible strategies to solve the problem.
3. Identify and implement the best solution strategy.
4. Monitor the implementation with respect to problem conditions and goals.
5. Achieve and communicate the predetermined goal.
6. Assess the solution (goal) for accuracy and reasonableness.
7. Check for procedural or computational errors. Then, if necessary, redefine the perspective and proceed with a new strategy.

Practice. Another element viewed as a possible factor in students' success in solving story problems is practice. Reys, Suydam, and Lindquist (1994) purposed that successful problem solvers must have many experiences in doing so. These authors reported research suggesting that children given many problems to solve scored higher on problem-solving tests than children given few. This finding supports that of Callahan and Glennon (1975), who pointed out after their review of research, that students showed gains in problem solving when merely presented with many problems to solve. They further concluded that students provided with systematic instruction showed even greater gains.

Cue Words. Another factor identified as an element which may influence the difficulty of story problems is cue words. Cue words are words such as "total," "in all," or "difference," which have been labeled by some as signals to tell the reader which operation to use (i.e., "total" would indicate addition and "difference" would indicate subtraction).

Stockdale (1989) conducted a study which suggested that when all other variables were held constant, the presence of cue words appeared to make story problems easier for students to solve. After Sowder and Sowder (1989) investigated the strategies used by students to solve story problems, they reported that most students used the cue word approach. In 1991 Stockdale reexamined the veracity of this strategy. Using three instructional premises, (a) all story problems contain a cue word; (b) all cue words indicate one arithmetical operation; and (c) textbooks series are consistent in their use of cue words, Stockdale tested the usefulness of the strategy. After compiling a list of commonly taught cue words, she analyzed best-selling textbook series for these words. Each story problem was examined for the presence of cue words. In addition to the cue words, the operation or multiple operations required to correctly solve the story problem were noted. Results of her investigation showed that none of the instructional premises was valid. Only 20-50% of the word problems examined contained cue words. Of those cue words, only two words, "percent" and "equal," were associated with one arithmetical operation. She also found that the textbooks varied in the use of cue words. These findings suggest that the presence of cue words does not appear to be a factor in successful solution of story problems. Stockdale concluded that the cue word strategy could not be recommended as the sole method for helping students become more efficient solvers of story problems.

In summary, researchers identified several factors believed to be influential in students' success when solving story problems. Although there is a lack of agreement on all factors which influence success, there is consensus on the point that the complex text of story problems makes them challenging to comprehend.

Relationship between Reading and Story Problem Solving

It has been suggested that students who perform straight computation fairly well may experience difficulty when asked to apply these same skills to written story problems. A review of the literature suggests that students are unable to translate story problems into numerical form due to difficulty comprehending what they read. Several researchers noted relationships between students' reading comprehension and story-problem-solving ability (Aiken, 1971; Balow, 1964; Earle, 1976; Krulik, 1980; Siegel, et al., 1989). Studies related to the role that reading and language skills play in the solution of story problems are presented in this section.

Research analysis by Jerman and Mirman (1974) indicated that errors in solving story problems in the middle to upper grades were more attributable to linguistic variables than in the lower grades. They proposed that direct reading instruction in the lower grades may have influenced these results.

O'Mara (1981) reviewed the research on the language contexts of mathematics, general reading ability, specific reading skills in mathematics, and the readability of mathematics materials. She concluded that nearly 35% of the errors on mathematics achievement tests were due to reading problems.

Similarly, Ballew and Cunningham (1982) found that 29% of a group of sixth graders identified reading as their difficulty in solving story problems. For this study these investigators established a classification scheme and specified four major areas in which students experienced difficulty when solving story problems. The areas specified were (a) computation skills, (b) problem interpretation, (c) reading, and (d) the ability to integrate computation with interpretation and reading into total solution. Their findings revealed that the inability to read story problems is a major stumbling block for students when they attempt to solve them.

Call and Wiggin (1966) studied the effectiveness of teaching reading in the mathematics classroom. A mathematics teacher with little background in reading instructed one group of students. This teacher concentrated on mathematics skills using the text and lecture without formal instruction in reading. An English teacher with little background in mathematics instructed another group of students. Although this teacher had limited reading training, the text and lecture method were supplemented with special instruction in translating words into mathematical symbols. Those students instructed by the English teacher were able to solve story problems more accurately than those instructed by the mathematics teacher. These researchers concluded that teaching reading, at least in the mathematics classroom, had a significant influence on students' acquisition of problem solving skills.

Muth (1984) compared the relative importance of reading ability and computational ability to the solution of story problems. The findings indicated that both reading ability and computational ability contributed to success in solving story problems. Reading ability and computational ability together accounted for about 54% of the variance in correct answers. Reading ability accounted for approximately 14% of the variance in correct answers. Computational ability accounted for approximately 8% of the variance in correct answers. The results of this study support the notion that reading ability plays an important role in the solution of mathematical story problems.

Henney (1970) studied the effect of special instruction in reading on solving story problems. This instructional approach was compared to supervised practice in solving story problems in a fourth-grade setting. Although both experimental groups improved significantly from pretest to posttest on the criterion measure, neither group achieved significantly higher mean scores on the posttest. The results of this study suggested that special instruction in reading skills is no more effective than supervised practice on students' ability to solve story problems. Since no control group was used in the study, it is not possible to determine if the improvement noted from pretest to posttest was a result of regular classroom instruction rather than either treatment. Henney further reported that neither specific reading abilities, general reading abilities, nor computational abilities were found to correlate more highly with the ability to solve story problems. The Stanford

Achievement Test Reading and Mathematics Subtests were administered to the subjects of Henney's study. The results were correlated with the scores on the subtests of the instrument used as the criterion measure. These findings are in contrast to findings of some other research in this area. The investigator noted the need for further research.

Brennan and Dunlap (1985) postulated that the traditional view of reading as a medium of words and mathematics as a medium of numbers is not practical. Reading is viewed as a process for identifying a message conveyed through written words, and mathematics is viewed as a process primarily concerned with computation. In reality, students must learn to integrate reading and mathematical skills using very similar thought processes and techniques in each area. Reading is a valuable tool for studying mathematics. These authors identified three primary factors causing students to experience difficulties in reading mathematical materials: (a) mathematical materials require more advanced reading levels than normally associated with the given grade level, (b) students are not adequately instructed in the processes for reading mathematics text, and (c) reading skills and processes are not taught in a manner that can be transferred from reading class to the mathematics class. Brennan and Dunlap argued that reading teachers need to teach students to read materials other than the traditional basal or literature books and that mathematics teachers must teach students to read mathematical materials. They pointed out that not only are the reading skills required in math texts one to three years above the grade level for which they are targeted, but also students must use a wide range of reading skills to read a story problem and decode its general message. Once the general message is decoded, it must be translated into the technical (mathematical) message. At this juncture a student must be aware of general and mathematical meanings of words (i.e., "left" may mean direction or remainder). After decoding the technical message in a story problem, students must then encode this message into symbolic sentences. These protracted processes, reading skills, different vocabularies, decoding and encoding skills, translation between vocabularies, and minimal context clues help explain why even students who are good readers experience difficulties with story problems. This may also help explain why the simplistic process for solving story problems frequently taught in elementary school does not enable students to become efficient at solving story problems.

To summarize, the preponderance of the literature points to a distinct relationship between reading skills and the ability to solve story problems. A significant number of errors made by students in the various studies were attributed to language-related difficulties. It has been noted that metacognitive skills and direct instruction in reading positively influence students' success in solving story problems. These findings imply a strong link between reading ability and the ability to solve story problems.

Reading Strategies for Story Problems

According to Culyer (1988) it has been established through research and widely accepted that success in reading is synonymous with the ability to understand written material. He proposed that the same relationship exists between mathematics and written material. He further contended that most teachers are unaware of these similarities and overlook obvious instructional implications.

Because of the powerful link between reading skills and efficiency in solving story problems, several reading strategies which have been adapted to help teachers convey information and provide opportunities that enable students to develop skills necessary for solving story problems are presented in this section.

ReQuest

Manzo (1975) developed one reading strategy called ReQuest to improve students' ability to solve story problems. This procedure was designed originally to encourage students to (a) formulate questions about material they were reading and develop questioning behavior; (b) adopt an active, inquiring attitude toward reading; (c) acquire purposes for reading; and (d) improve their independent reading comprehension skills. Manzo suggested that students' abilities to formulate questions and set purposes for reading facilitated an active, inquiring attitude. Manzo argued that the components of ReQuest are essential if students are to develop the ability to use a problem-solving approach in other contexts (Tierney, Readence, & Dishner, 1990). When applied to story problems, ReQuest requires students to read each sentence of a story problem individually and then question other students for clarification. Manzo claimed that this process improved students' success in solving story problems.

PQ4R

Maffei (1973) suggested that success in solving story problems is attained by adapting a study skills device called SQ3R (Survey, Question, Read, Recite, and Review), originally developed by Robinson (1946). A variation of this device called PQ4R (Preview, Question, Read, Reflect, Recite, and Review) was advanced by reading specialists Thomas and Robinson (1972) using slightly different interpretations for each heading and changing the third "R" from "Recite" to "Rewrite." Maffei applied the PQ4R strategy to solving story problems in a high school algebra class and then asked the students to evaluate the plan. The students compared this approach to their previous study of story problems. The results indicated that average and below average students favored the PQ4R method because it gave them a system for solving problems they had previously found obscure. Also it gave them a place to start even if they did not get the correct answer.

According to Maffei (1973) the PQ4R strategy, when applied to story problems, stresses a careful reading and rereading of the problem with emphasis on mathematical word and phrase meaning as they relate to the problem as a whole. He cautioned that use of the strategy would not guarantee correct results, but would allow students to break the story problems into comprehensible parts and set the problems up to more easily reach solutions. The students in this experiment got an outline for each story problem. Then they applied PQ4R to each problem using the following steps:

1. Preview. The students read the problem and wrote down the main idea. They defined all unfamiliar words using either context clues, a dictionary, or a discussion with the teacher. Students were encouraged to keep a list of new vocabulary words for future reference.

2. Question. The students reread the problem and recorded the specific question they were attempting to answer.

3. Read. In the third reading the students identified phrases and sentences related to the question in Step #2.

4. Reflect. The students thought about what type of story problem they were facing. They asked themselves self-formulated questions. (e.g., "Is it a geometry problem?) Thought focused on the basic unknown quantity.

5. Rewrite. The students rewrote the numerical information of Step #4 into an equation, then solved it.

6. Review. The students checked the equation and examined the entire problem to see if the solution was reasonable.

Maffei (1973) predicted that teachers would experience greater success using the PQ4R strategy with average to below average students. It was his experience that most above average students had their own strategies and should not be discouraged from using them. Maffei also anticipated that following repeated practice the outline sheet could be abandoned because the skills would be implanted.

Language Experience

The Language Experience approach to teaching reading is based on the premise that language is used to communicate thoughts, ideas, and meanings. Teachers who subscribe to this method believe that children should work in their own language.

The complex and often unfamiliar language of story problems make them difficult to read and hinder students' success. Success is documented through studies adapting the language experience strategy for solving story problems (Cohen & Stover, 1981; McCabe, 1981)

Ferguson and Fairburn (1985) described a teacher who used the Language Experience approach to facilitate solving story problems. She presented simple computational problems first, and then had students write story problems to match these operations. The teacher then wrote the stories on an experience chart providing a concrete connection between mathematics and the real world. This approach increased students' proficiency, enabling them to eventually reach success independently.

McCabe (1981) applied a language experience approach to the comprehension of mathematics textbook materials. The results of this study indicated that students' comprehension of mathematics materials improved when passages were patterned after their own syntactic structures. This study was conducted in a ninth grade mathematics class. The investigator assessed the students' comprehension of a textbook passage using a cloze procedure. Students explained a section of the textbook in their own words. The passage was then repatterned by McCabe using the syntactic patterns identified in the students' explanations. Students performed better on tests of comprehension with text material written in their own oral language patterns.

Directed Reading Activity

Many reading specialists advocate the Directed Reading Activity as an effective strategy. Greabell and Anderson (1992) successfully applied this strategy to solving mathematical story problems. The six elements employed in their study were:

(a) Vocabulary development. Students inferred the mathematical definitions of the words in the problem. They distinguished between common language usage of a word and its mathematical meaning (i.e., equal and equivalent).

(b) Background and motivation. Building background and establishing motivation enhanced understanding of mathematical concepts and processes.

(c) Purpose for reading. Setting the purpose for reading focused the students' attention by directing them to look for specific information in the story problem.

(d) Guided silent reading practice. This allowed for feedback reinforced appropriate problem-solving skills.

(e) Questions to determine comprehension. Problems restated in their own words lead students to form a clearer mental image.

(f) Selection reread orally. This step permitted students to determine if the solution computed made sense. They then verified whether their answer was logical and reasonable. According to Graebell and Anderson if students have the prerequisite computational skills, the directed mathematics activity leads them to the successful solution of story problems. They further argued that, when applied to mathematics, this strategy builds independent problem-solving skills in students.

Curry (1989) also recommended the Directed Reading Activity to systematize students' approach to the comprehension of the text of story problems. She offered a simplified three-step plan. First, she promoted readiness through motivation and activation of prior knowledge. Next, she recommended development of the vocabulary. Finally, she outlined questioning techniques which provided the purpose for reading the story problem.

Graphic Organizers

Rubens (1980) suggested that the problems students experience in reading mathematics need to be confronted in nontraditional ways. After reviewing studies dealing with the difficulties that students experience, Rubens recommended that teachers explore the relationships of text and illustrative material as one approach to help students learn to read mathematics. One type of illustrative material used successfully in content area reading comprehension is the graphic organizer. Graphic organizers use spatial arrangements and wording that graphically organize key conceptual relationships of expository text (Simmons, 1988). (See Appendix E.)

Brasselton and Decker (1994) used graphic organizers with a group of fifth graders in a mathematics classroom to improve their ability to solve story problems. They observed that these students typically used the cue word strategy to solve story problems rather than reading the story problems for meaning. The students looked for cue words such as "in all," "total," "left," and "remain," and then used the numerical relationships of the numbers to select an operation. These investigators attempted to assist students in viewing story problems more holistically through the use of graphic organizers.

The fifth graders were first taught graphic organizer strategies, and then given story problems to solve using this process. The first step was to restate the story problem question in their own words. Next, they analyzed the problem to identify the necessary information for solving the problem. The third step required use of the graphic organizer to plan mathematical calculations. The next step focused on the computational skills.

This was when students performed actual calculations. At the last step students scrutinized the answer to determine its reasonableness. This stage is vital, though frequently overlooked by mathematics teachers. The results of the study revealed that the use of the graphic organizer improved the problem solving skills for students of all ability levels.

The most beneficial aspect of this strategy appeared to be the systematic approach to analyzing the story problems. The organizer offered a framework that gave students confidence in their ability to succeed. This process also required a careful thought process prior to mathematical operation performance. Brasselton and Decker (1994) concluded that the most significant factor in the success of the graphic organizer strategy was that it forced students to think through each problem systematically. They also noted that it was effective with students who had weak problem solving skills due to poor visual organization of the problem-solving process. The graphic organization required students to express their understanding in written language. Also noted was the cooperative learning aspect of the study which helped students with inferior verbalization skills to learn from others who were more proficient problem solvers. The investigators further concluded that many strategies which integrate language and mathematics skills have the power to increase independent problem solving abilities. They proposed that many of the reading strategies, which are effective in content areas such as social studies and science, may also work in reading mathematics. They offered graphic organizers as an efficient strategy for solving story problems.

According to Berkowitz (1986) students in the sixth grade benefited from instruction and practice in graphic organization of text. She conducted a 6-week investigation that used two experimental methods of instructing sixth-grade students to use the organization of ideas in content reading as a framework for studying. She compared them with study methods which functioned as controls and did not focus on text organization. The findings of her investigation suggested that direct instruction in using an author's organization of ideas in content material as a framework for study may enhance recall of expository information. The experimental procedure of map-construction (a graphic organizer) appeared to foster significantly greater recall of textbook passages than the procedure of answering questions. These results indicated that a study strategy which helped students focus on text structure facilitated greater recall than a conventional questioning procedure. Based on these findings, Berkowitz recommended that instruction and practice in map-construction be provided in middle-grade classrooms to enable students to become proficient at constructing maps to add this technique to their study skills.

Hurad (1983) examined the effect of graphic postorganizer training on sixth-graders' ability to learn independently from text. The graphic postorganizer is a graphic organizer used to organize text after it is read. Students given the graphic postorganizer treatment constructed better graphic organizers than those who received no training. However, the training in graphic postorganizers did not result in significantly higher scores on independent learning ability. Hurad concluded that it was possible to train students to graphically organize text, but it did not appear to increase their general learning from expository text.

Other researchers have looked at the effectiveness of the graphic organizer in instruction. Simmons, Griffin and Kameenui (1988) compared the effects of three instructional approaches using the graphic organizer. The purpose of the study was to determine the most effective procedure for facilitating sixth graders' comprehension and retention of science content. The three procedures were: (a) utilization of teacher-constructed graphic organizers before text reading, (b) utilization of teacher-constructed graphic organizers after text reading, and (c) utilization of a traditional form of instruction consisting of frequent questions and text-oriented discussion interjected before, during, and after text reading. The results indicated that all three groups were comparable on daily measures of comprehension. The findings suggested that the pregraphic organizer (graphic organization before reading) group out performed the postgraphic organizer (graphic organization after reading) group on the summative measure. Results further showed that teacher-constructed graphic organizers (whether presented pre or post reading) were no more effective than traditional instruction. Neither the graphic organizer nor traditional instruction resulted in acceptable levels of comprehension and retention of expository text. Although the study did not conclusively support the statistical significance of graphic organizer instruction, the pregraphic organizers consistently yielded the highest mean performance of the three treatments. The investigators concluded that the findings of their study supported a refined and intricate use of the pregraphic organizer as an aid to comprehension and recall.

These findings lend support to those of Estes, Mills, and Barron (1969), who concluded that pregraphic organizers significantly enhanced comprehension of expository text when compared to the effect of purpose-setting questions. A study conducted by Barron and Cooper (1973), however, found the prereading graphic organizer to be no more effective than advance organizers or no prereading treatment. Prereading graphic organizers, the visual organization of text presented before reading, were compared to advance organizers, short reading passages preceding the actual text, in this study.

According to Moore and Readence (1980; 1984) a review of the literature on graphic organizers indicated advantages of graphic organizer treatments. In contrast to the Simmons, Griffin, and Kameenui study (1988), their statistical syntheses revealed support for the use of graphic organizers in the post-reading position. They found that students exposed to postreading graphic organizers learned more than those students exposed to prereading graphic organizers, particularly when vocabulary was the criterion variable. However, one observed advantage of using prereading organizers was that teachers involved in the studies felt better prepared to teach their lessons after constructing the graphic organizer.

Though the research on graphic organizers appears to be inconclusive, there is support for the notion that using this strategy to assist students in organizing their thoughts improves their ability to solve story problems. Numerous other strategies offer promise to help students attack story problems.

Suydam (1982) offered encouragement when she found that specific problem-solving strategies can be taught. She also found that such strategies used more frequently, increased the likelihood of success. She recommended teaching a variety of strategies to give students a larger knowledge base from which to draw -- hence, increasing the likelihood of success.

In summary, there appears to be agreement within the literature that specific reading strategies adapted for use in a mathematics context enhance students' ability to solve story problems. It also seems that leaders in the fields of reading and mathematics are recognizing that students are active constructors of meaning, not simply passive recipients of knowledge. Emanating from research is a growing emphasis on the functionality of reading, writing, and mathematics. The skills in each area must be viewed as tools for learning, not just ends in themselves (Jongsma,1991).

Summary

The intent of this chapter was to (a) point out the disparity between children's ability to perform mathematical computations and their ability to solve story problems; (b) discuss factors influential to the solution of story problems; (c) present evidence that reflects a relationship between general reading ability and successful problem solving; and (d) suggest specific reading strategies that enhance students' ability to solve story problems.

The literature suggested that American students experience difficulty applying simple computational skills to problem solving situations (Carpenter, et al., 1980; Gleason, Silbert, & Carnine, 1990; Kouba , et al., 1988; Kroll & Miller, 1993). There seemed to be general agreement that literacy factors such as difficulty of the text, syntactic and semantic organization of the text, vocabulary, and even use of the textbook influence students' performance (Laborde, 1991; Muth, 1993; Ratekin et al., 1985; Romberg & Carpenter, 1986; Singer & Donlan, 1989; Moyer et al, 1984; 1984;). Some studies presented evidence that students' reading comprehension relates to their story problem solving ability (Ballew & Cunningham, 1982; Jerman & Mirman, 1974; McNinch, 1982; Muth, 1984; O'Mara, 1981; Skrypa, 1979). And finally, other studies provided evidence that instruction in graphic organizers increased comprehension of expository text, and specific reading skills instruction enhanced students' ability to solve story problems (Berkowitz, 1986; Brasselton & Decker, 1994; Estes, et al., 1969).

This literature supports the need for an experimental study to investigate the effects of analytic reading skills taught in a mathematics context. It was suggested that reading skills adapted for the mathematics classroom improved students' ability to solve story problems. Instructional approaches such as those used in the present study may extend knowledge concerning reading instruction in mathematics.

Chapter 3

Methodology

The purpose of the present study was to compare the effects of two instructional approaches on students' ability to solve story problems. Instruction in utilization of graphic organizers in conjunction with specific analytic reading skills was compared to instruction in specific analytic reading instruction alone and to the absence of either treatment on sixth graders' ability to solve mathematical story problems. This chapter describes the research design, the setting, experimental conditions, and materials and procedures used in the study.

Research Design

The study employed an experimental/control, three-group design. The first experimental group (Group 1) was one intact sixth grade class. Another intact sixth grade classroom served as the second experimental group (Group 2). A third intact sixth grade classroom acted as the control group (Group 3). Diagrams which explain the research design are found in Table 1.

Variables

Independent Variable. The independent variable in the research study was instructional treatment. There were two

Table 1

Diagram of the Experimental Design

Groups ($\underline{N}$ = 67)	Covariate	Experimental Variable	Posttest
Group 1 ($\underline{n}$ = 23)	O_1	X_1 (Reading and graphic organizer)	O_2
Group 2 ($\underline{n}$ = 24)	O_3	X_2 (Reading only)	O_4
Group 3 ($\underline{n}$ = 20)	O_5	No treatment	O_6

levels of treatment which consisted of instruction in the use of graphic organizers with specific analytic reading skills for solving story problems and instruction in the use of specific analytic reading skills only. These were compared to the absence of either of these approaches.

Dependent Variable. The dependent variable used to measure the effects of the treatment was the accurate solution of story problems, referred to as achievement. The Story Problems Test, an instrument developed by the investigator, measured the ability to solve mathematical story problems. The Story Problems Test appears in Appendix A.

Covariate. The covariate was the achievement score derived from the preadministration of the Story Problems Test. Specifically, these pre raw scores from the Story Problems Test were used to adjust intact group differences in problem solving ability, to control for differing abilities within and across groups.

The Story Problems Test is an instrument designed and pilot-tested by the investigator to measure sixth graders' ability to use certain reading skills in solving story problems. The test was the criterion measure in testing the hypotheses of the present study. It was piloted in another school of similar size and ethnicity in order to select items which were most reliable. The reliability coefficients calculated for the two groups are listed in Table 2. After the test was piloted and unreliable items deleted, it served as the pre- and posttest measures for the study.

The investigator was unable to locate a commercial, standardized instrument which measured skills in solving mathematical story problems. There are tests available which measure general mathematics ability as well as computation skills and knowledge of mathematical concepts. However, none of these tests gave a score for both reading and solving mathematical story problems.

Analysis of the text of various types of story problems promoted identification of several specific reading skills relevant to their solution. The reading skills measured by the Story Problems Test included recognizing and understanding vocabulary, determining the main idea, and recognizing what is being asked. Other measured skills included identifying necessary information for solution of the problem, distinguishing between data relevant and irrelevant to the solution, and recognizing when given information is insufficient for a solution. Also measured were skills for inferring a mathematical operation that is appropriate for relating essential information and solving the problem, as well as skills for determining the appropriate sequence of operations when several steps are necessary for a solution. Also, included was the ability to interpret the result of completed computation in terms of the question stated in the problem.

Items for the Story Problems Test reflect the text and format of story problems found in several leading mathematics textbooks. Textbooks analyses revealed types of problems sixth graders typically solve during the third month of school. Problems written for use in this test were of similar format and of comparable difficulty to those found in the textbooks. Multiple choice questions measured the reading skills required for solving the story problems.

Three subtests comprise the test. The first subtest required the use of straight mathematical computation skills to measure the students' ability to perform mathematical computation skills. The calculations required in this subtest were those necessary to solve the story problems. The purpose was to test the students' ability to work with the various operations at increasingly difficult levels. No story problems appeared in this section of the test.

The second subtest contained story problems with multiple choice questions designed to measure the reading skills involved in solving the story problem. No computation was required in this subtest. The purpose of this subtest was to measure the reading skills necessary for solving the story problems.

The third subtest consisted of story problems. These were the same story problems that appeared on the reading subtest, but the students solved the problems mathematically. They selected the item with the correct mathematical answer and label from given multiple choice responses. The purpose of this test was to determine if the students were able to synthesize the computational and reading skills as a means of successfully solving mathematical story problems.

The pilot instrument consisted of 95 items. These 95 items composed the three subtests. There were 35 items on the computation subtest, 30 items on the reading subtest which had to be answered in terms of reading comprehension, and the same 30 items on the story problem solution subtest which had to be read, interpreted, and answered mathematically.

Three colleagues of the investigator with backgrounds in mathematics, statistics, and test construction scrutinized the test. A sixth-grade classroom teacher also reviewed the test. All parties judged that the test had content validity.

A Monroe City School District school of similar size and ethnicity to the site of the experimental study hosted the pilot test. Forty-nine sixth graders in two intact sixth grade classes at Sallie Humble Elementary School served as the subjects for the pilot testing. Test administration occurred on three consecutive days -- September 27, 28, and 29, 1995. The students completed one subtest each day. All students completed all items on each subtest. The investigator administered the tests in the students' regular classroom setting.

The reliability coefficient for the pilot administration of the Story Problems Test appears in Table 2. The Pearson product-moment correlation coefficient and the Spearman-Brown Prophecy formula measured internal reliability. A single administration of a single form was divided in half for scoring purposes. The split-half method (Linn & Gronlund, 1995; Popham, 1993) was implemented to score the even-numbered and the odd-numbered items separately. This produced two scores for each student which were correlated. The Pearson product-moment showed a correlation of .89 and the Spearman-Brown Prophecy formula showed a reliability correlation of .94, which was highly significant (p <.05).

An item analysis of the responses of the students provided details used in the selection of items for the final form of the Story Problems Test. The responses, once scored for correctness, were ranked from highest to lowest. Examination of the upper one-third of the scores and the lower one-third of the scores allowed

Table 2

Pearson's Correlation and Reliability Coefficient for Groups in the Pilot Administration of the Story Problems Test ($\underline{N}$ = 49)

Test	Pearson r	Spearman-Brown r
Pilot Version	.89	.94

distinction between items the majority of the upper one-third answered incorrectly, items the majority of the lower one-third answered correctly. These items were identified as possibly too difficult and too easy, respectively.

Next, the difficulty of each item was measured by the percentage of students who answered it correctly. Items noted were those answered correctly by fewer than fifty percent of the students in the pilot administration.

Finally, calculation of discriminating power for each item determined the degree to which it discriminated between students with high and low achievement. The number of students in the lower one-third who answered an item correctly was subtracted from the number of students in the upper one-third who answered an item correctly. The difference was then divided by one-half the total number. Noted were items with low discriminating power. A list composed of items that appeared on all three measures, identified items to exclude from the final form of the Story Problems Test. The final form used 40 items from the original 95. As illustrated by the reliability coefficient measures and based on opinions of content specific experts, this was a reliable and valid instrument for the present study.

Description of the Setting

School

The sixth grade, consisting of three classes at J. S. Clark Math, Science, Computer Magnet School, served as the site for the present study. Clark Magnet School is a public elementary school in Monroe, Louisiana, the only magnet school in the city. Clark was originally established in 1989 to facilitate the integration of that school in particular and the Monroe City School System in general. Initial attempts were unsuccessful. After 4 years the school was 100% minority and the school district remained 85% minority. The redesign of Clark Math, Science, Computer Magnet School in 1992 was in response to a federal court order requiring integration of the school or mandated redistricting of the entire school system to achieve integration. A committee of educators, parents, and concerned citizens worked for a year with a nationally recognized consultant to design a curricular program that would attract non-minority students.

Today, Clark has a total student population of 500 students. The student body is 60% minority and 40% non-minority with 300 and 200 students respectively. There are 436 regular education students and 64 special education students. Approximately 46% of the student population participate in the free or reduced-cost lunch program.

Personnel

The staff at Clark is comprised of 32 certified personnel and 8 non-certified personnel. Included in this number are a principal, assistant principal, program coordinator, and guidance counselor.

The sixth grade is departmentalized by content area. The three sixth-grade faculty each teach different content areas. The heterogeneously grouped sixth grade students move to each of the different sixth-grade faculty who teach separate disciplines throughout the day. The faculty member who teaches reading as a part of the language arts block is an African American female with an Ed. S. degree and has taught for 18 years. The faculty member who teaches mathematics, as well as science, is an African American female with an M. Ed. degree. She has taught for 20 years. The third faculty member is a white female with a B. A. degree and has taught for 32 years. She teaches social studies and physical education.

Subjects

The sixth grade at Clark consists of 67 students. The classes are 55% minority and 45% non-minority with 37 and 30 students respectively. There are 49 regular education students and 18 special education students. Approximately 58% of the sixth grade participate in the free or reduced-cost lunch program.

The sixth grade is heterogeneously grouped into three sections. One section contains 23 students with an ethnic composition of 11 minority and 12 non-minority (see Table 3). Ten students participate in the free or reduced-cost lunch program. Another section contains 24 students with an ethnic composition of 13 minority and 11 non-minority. Fifteen students participate in the free or reduced-cost lunch program. The third section contains 20 students with an ethnic composition of 13 minority and 7 non-minority. Sixteen students participate in the free or reduced-cost lunch program.

Experimental Conditions

The three sections of the sixth grade represented two experimental groups and one control group. Random selection assigned the three intact classes to the two treatment groups and the control group. Group 1 received Treatment One, Group 2 received Treatment Two, and Group 3 received no treatment. All three groups received reading and mathematics instruction during a regular classroom setting each day. In addition to regular reading and mathematics instruction, these groups received additional instruction as described below.

Table 3

Student Data for Experimental and Control Groups

Groups	Ethnicity				Totals
	Minority		Non-Minority		
	N	%	N	%	
Group 1	11	48%	12	52%	23
Group 2	13	54%	11	46%	24
Group 3	13	65%	7	35%	20
Totals	37	55%	30	45%	67

Treatment One

Experimental Group 1 met for 30 minute lessons in which instruction in utilization of graphic organizers and specific analytic reading strategies to solve story problems was delivered by the investigator. An example of the completed graphic organizer used in the study appears in Appendix F. Instruction delivered to the whole group provided individual assistance as needed. Student work on story problems was checked and collected each class period.

Treatment Two

Experimental Group 2 received instruction in specific reading skills only. This group received 30 minute lessons in special instruction in specific analytic reading skills delivered by the investigator. These skills were used to solve story problems. Instruction delivered to the whole group included individual assistance as needed. The investigator checked and collected the problems for each session.

The story problems solved during the experimental lessons were the same for both treatment groups. Examples of story problems used in the study appear in Appendix E. Each group solved three to five problems during each lesson. The Experimental Group 1 received one to two fewer problems because the additional instruction and utilization of graphic organizers took more time than that needed to instruct Experimental Group 2.

Control Group

The Control Group met for 30 minutes during a study period type setting. Students used this time to complete regular classroom assignments, visit the library, or engage in other academic activities. This group received no instruction in reading, mathematics, graphic organizers, or story problems in addition to regular classroom instruction.

Lessons for the Treatment Groups

The lessons for Experimental Groups 1 and 2, taught by the investigator, were in addition to the regular reading and mathematics instruction given each day by the established reading and mathematics classroom teachers. The investigator instructed both treatment groups in order to control for the teacher variable. The format for the lesson plan appears in Appendix D. The Control Group met with their classroom teacher and worked on usual study hall activities. No reading or mathematics instruction was given during this period.

The purpose of the instruction given to the students in the treatment groups was to strengthen their ability to read and solve story problems. In Experimental Group 1, the lesson stressed skills of spatial organization of the key concepts in the text of story problems. Appendix B contains an overview of the lessons for Treatment One. Organizing the information given and recognizing relations which existed in view of the question asked were stressed. Also stressed were skills in recognizing and understanding vocabulary, selecting the main idea, recognizing the question asked in the problem, noting when information was sufficient for a solution to be reached, noting when the problem contained information not relevant to the solution of the problem, reading to note sequence, predicting outcomes, and formulating a sentence which answered the question in the problem.

The students in Treatment One were given a teacher-constructed, prereading graphic organizer which structured the key concepts of one story problem. The example was explained and discussed. Another story problem was presented and students completed a blank graphic organizer as the investigator posed questions designed to enable them to apply analytic reading skills through the following steps:

1. Vocabulary development. First students defined unfamiliar terms or vocabulary.

2. Main idea. Next, students summarized what they thought the story problem was about. They wrote the gist of the problem in their own words.

3. Question. Students then identified and restated the problem question. They paraphrased what the story problem asked them to find out.

4. Relevant and irrelevant data. Students next distinguished between information relevant and irrelevant to the solution of the problem. They identified necessary information as well as any extraneous information included in the text of the story problem.

5. Inferences. Students then inferred mathematical operations by deciding which operations to perform and in which sequence if more than one operation was required.

6. Interpreting. Finally, students interpreted the results in terms of the question asked. They wrote a complete sentence that answered the story problem question.

Students solved one story problem as a guided practice activity at the beginning of each lesson and then others as independent practice. Students received blank, teacher-constructed prereading graphic organizer outlines to use as they worked through each story problem. An example of the graphic organizer used in the present study appears in Appendix E. The investigator monitored students' work closely and provided individual assistance as needed. The problems were checked as students completed them and then they were collected to be placed in each students' portfolio.

Instruction delivered at the beginning of the study involved teacher-constructed graphic organizers presented both before and after reading story problems. As the study progressed, students constructed their own organizers. Students used demonstrated reading skills to complete the graphic organizers and solve given story problems.

Experimental Group 2 received a series of lessons which involved instruction in specific analytic reading skills and story problems to solve. Appendix C presents an overview of the lessons for Treatment Two. The same reading skills as those taught in Experimental Group 1 were taught in Experimental Group 2. The same procedures and steps as described above were used to solve story problems except there was no graphic organizer. Skills included recognizing and understanding vocabulary, selecting the main idea, recognizing the question asked in the problem, noting when information was sufficient for a solution to be reached, noting when the problem contained information not relevant to the solution of the problem, reading to note sequence, making inferences, and formulating a sentence which answered the question. Reading skills, like those used in PQ4R, Language Experience, and Directed Reading Activity, helped students solve story problems. One story problem provided guided practice for each lesson. Students solved other story problems independently. The investigator led the students through the solution of the first story problem using the analytic reading skills. The intent of this procedure was to help the students decide what the story problem was about, what it asked them to find out, what data they needed to solve the problem, and how to infer the operation. Students answered each story problem in a complete sentence directly related to the question statement of the problem. The investigator monitored students' work closely and provided individual assistance, as needed, to check all completed problems. Feedback enabled students to correct any errors before the paper was collected and placed in their portfolio.

The investigator wrote the story problems presented during the lessons in both treatment groups. Various leading textbook series, including the one currently adopted by the Monroe City School District, were used as resources in writing these story problems. Examples of these story problems appear in Appendix G.

The investigator used the same basic lesson plan for each treatment. Lesson plans for Experimental Group 1 reflected instruction in how to use the graphic organizer and analytic reading skills. The lesson plans for Experimental Group 2 reflected instruction in analytic reading skills only. The problems used for the treatment lessons were the same for both groups and organized so that each lesson was slightly more complex than the one preceding. The problems for each lesson involved new skills as well as those taught in the preceding lesson.

Each of the treatment groups received twenty lessons over a four-month period. Each of the lessons was at least thirty minutes long, providing over ten hours of instruction for each treatment group.

Teachers' Records

The three sixth-grade classroom teachers were asked to keep a record of activities and concepts covered during regular classroom instruction. Examination of these records enabled the investigator to judge that improvement in problem solving was not a result of classroom instruction but rather a result of work done in the experimental lessons.

The same teacher delivered regular mathematics instruction to all three groups of students. Another teacher, also common to all three groups, taught reading. A third teacher guided study hall activities for the control group. These three classroom teachers were asked to keep a record of activities and topics covered during the reading, mathematics, and study hall (control) sessions. Each teacher received a record sheet for the dates of the study with spaces to record topics and activities. Each was to specify lesson objectives and instructional activities for the duration of the study. The mathematics and reading teachers were not aware of the purpose or intent of the experimental study. The teacher who monitored study hall activities for the control group, however, was fully cognizant of the purpose of the study. The investigator requested that no instruction in reading or mathematics be delivered in the control setting.

Both the mathematics and reading teacher provided the requested information. Examination of their records indicated that topics and activities covered in all of their classes were the same. Thus, whatever effect the regular classroom instruction may have had on the students' ability to solve story problems was equally distributed among the three groups.

The teacher who guided the study hall (control setting) also provided a detailed explanation of activities and topics covered. The only direct instruction in this setting was in map skills and research skills. As requested, this group received no instruction in either reading or mathematics.

Hypotheses

The experimental research study tested the following null hypotheses at the .05 level of significance. One major null hypothesis was established to ascertain whether any significant difference existed among the adjusted post means for all three groups. One minor hypothesis tested the post-mean differences between the two treatment groups. A second minor hypothesis assessed adjusted post-mean differences between the lower scoring treatment group and the control group. The third minor hypothesis concerned whether relationships existed between performance on content subtests of the Story Problems Test for each group in the study.

Major Hypothesis

There is no significant difference in the adjusted post-mean scores on tests of ability to solve story problems among the following groups: Students who receive instruction in utilization of graphic organizers in conjunction with analytic reading strategies (Group 1); those who receive instruction in analytic reading strategies (Group 2); and those who receive no treatment (Group 3).

Minor Hypotheses

The utilization of graphic organizers enables students to structure key concepts of text to facilitate comprehension and recognition of relationships in expository text. These skills influence the successful solution of story problems. The fundamental supposition of the present experimental study was that the ability to read story problems is an important factor influencing students' success in solving story problems. Specific analytic reading skills are factors in the successful solution of story problems. The following minor hypotheses focused on these ideas:

Minor Hypothesis One. No significant difference exists in the adjusted post-mean scores of tests of ability to solve story problems between students who receive instruction in utilization of graphic organizers in conjunction with reading strategies (Group 1) and those who receive instruction in only reading strategies (Group 2).

Minor Hypothesis Two. There is no significant difference in the adjusted post-mean scores on tests of ability to solve story problems between students who show less achievement from treatment effect and those who receive no treatment.

Minor Hypothesis Three. There is no significant difference in the correlation coefficients between the specific reading abilities measured by the Story Problems Reading Subtest and the ability to solve story problems as measured by the Story Problems Solving Subtest, and between computation ability as measured by the Story Problems Computation Subtest and ability to solve story problems as measured by the Story Problems Solving Subtest.

Data Collection

Data collection occurred over a four-month period beginning October 16, 1995, and ending January 10, 1996. The investigator administered the pretest, used as the covariate in the study, to the subjects on October 16, 1995. All subjects completed all items of the instrument.

The three sections of the sixth grade represented one control group and two experimental groups ($N = 67$). These groups received regular reading and mathematics instruction during their normal classroom settings. They attended reading and mathematics classes as usual and received instruction from their regular classroom teacher for those particular subjects. All three groups (the control and the two experimental) had the same classroom teacher for regular instruction in reading and mathematics. This arrangement controlled for the variable of instruction received outside the experimental setting. Thirty-minute sessions had been set aside each day for instruction in French. For the duration of the study, the students did not attend French class, but stayed with their social studies teacher where the investigator delivered treatment lessons. Experimental Group 1 received the treatment of instruction in utilization of graphic organizers in conjunction with specific analytic reading skills in solving story problems during this additional period. Experimental Group 2 received the treatment of instruction in specific analytic reading strategies to solve story problems during this period. In addition to normal instruction, the Control Group (Group 3) received a study period. Students worked with their social studies teacher on study hall activities.

The investigator administered the posttest on January 10, 1996. All subjects completed all items of the posttest which was the same instrument as the pretest.

Data Analyses

Data measured at the interval level used an analysis of covariance (ANCOVA) with the pretest as the covariate.

The basic premise of the present study was that the ability to read story problems is an important factor influencing one's success in solving them. The hypotheses were developed based on this concept. The major hypothesis states that there is no significant difference in the adjusted mean scores on tests of ability to solve story problems among students who receive instruction in utilization of graphic organizers in conjunction with analytic reading strategies, compared to those who receive instruction in analytic reading strategies only, and those who receive no such instruction.

To determine if differences among mean scores made on the posttests by children in the three groups were significant, an analysis of covariance (ANCOVA) tested the data. This statistical procedure was selected because: a) the study was conducted on site where the students were pre-grouped for regular classroom instruction and the subjects for each of these groups could not be randomly assigned; b) pretest data were available to use as the covariate; and c) linear regression was assumed due to a significant relationship between the covariate and the dependent variable.

Analysis of covariance (ANCOVA) adjusts post means to control for any differences that may exist in initial achievement scores. This statistical measure is appropriate when comparing the mean scores of three intact groups. A one-way analysis of variance (ANOVA) on the pretest scores yielded a computed $\underline{F}$-ratio of 3.08 which did not exceed the critical $\underline{F}$ of 3.15 indicating that no significant difference existed among the pretest scores used as the covariate in the study. The numerical differences supported the need to use ANCOVA.

Also, there existed a relationship between the covariate and dependent variables in the study. A correlation of .74 between the covariate (pretest) and dependent variable (posttest) for Group 1 was determined by using Pearson product-moment correlation. A correlation of .77 for Group 2 and a correlation of .78 for Group 3 was determined. The group pretest means, standard deviations, and correlation coefficients for covariate and dependent variables appear in Table 4. All three correlation coefficients were significantly different from zero according to Table G in Ferguson and Takane (1989, p. 560).

Analysis of covariance (ANCOVA) is particularly appropriate in curriculum studies such as this one when it is not possible to equate groups at the beginning of the experiment and when assumptions of common slope and linearity may be made. The use of this design controlled statistically any initial differences in the students' test scores which were present and which might have confounded differences between the three groups (Glass & Hopkins, 1984).

In the present study, the analysis of covariance (ANCOVA) adjusted the final test means on the basis of the covariate (pretest) and then compared those adjusted post means to determine if they were significantly different from one another (Glass & Hopkins, 1984). The Tukey ad hoc comparison tested the adjusted means as a follow-up procedure (Ferguson and Takane, 1989).

Table 4

Means, Standard Deviations and Correlation Coefficients for Covariate and Dependent Variables of Groups (N = 67)

Tests	Group	n	Mean	S.D.	Pearson r
Pretest	1	23	26.30	6.58	.74
Posttest	1	23	30.22	5.90	
Pretest	2	24	25.75	7.66	.77
Posttest	2	24	29.00	6.32	
Pretest	3	20	21.55	5.84	.78
Posttest	3	20	22.50	6.50	

Chapter 4

Analyses of Data

This chapter presents the findings of the study. Results from testing the major and minor hypotheses are delineated through narrative text. Tables and figures present results of statistical analyses. Rationale for selection of particular statistical procedures used in the study is discussed.

The present study compared the effects of instructional approaches on students' ability to solve mathematical story problems. Instruction in utilization of graphic organizers in conjunction with specific analytic reading skills was compared to instruction in specific analytic reading skills alone and to the absence of either treatment on sixth graders' ability to solve mathematical story problems.

Experimental Group 1 received instruction in graphic organization of the text of story problems and in analytic reading skills. Experimental Group 2 received instruction in analytic reading skills only. Group 3, the Control Group, received no special instruction in graphic organizers or analytic reading skills. This group worked on study hall activities (i.e., completing homework, library research, or free reading) with a regular classroom teacher in lieu of treatment instruction by the investigator.

All three classes were in the same school. Because the investigator worked with intact groups rather than with randomly assigned subjects, a pretest was administered to establish baseline data and measure abilities to solve story problems. The pretest scores served as a statistical control (covariate) in the data analysis.

The independent variable was instructional treatment. The instructional treatment consisted of two levels, specific instruction in the use of graphic organizers in conjunction with instruction in analytic reading skills, specific instruction in analytic reading skills alone, and the absence of either treatment. The dependent variable, used to measure the effects of the independent variable, was achievement on the post administration of the Story Problems Test. The reliability coefficients for the pilot version of this instrument appear in Table 2.

A Macintosh computer and software titled Statistics with Finesse (Bolding, 1984) analyzed data from the study. Means and standard deviations were computed for the dependent variable. Correlation analysis determined the significance of the covariate employed in the covariance analysis. The Tukey post-hoc analysis reduced the risk of accepting differences as true differences when they may have occurred by chance. Tukey's "honestly significant difference" (HSD) method (Ferguson and Takane, 1989) for comparison tested the secondary post-mean differences from the analysis of covariance. This method is a very powerful ad hoc comparison test, which adjusts the level of significance to reduce the influence of chance when more than one comparison is involved. The formula for Tukey's "honestly significant difference" (HSD) method appears in Appendix H. Since the present study was an evaluation in an education setting, the .05 level of significance was adopted.

The primary intent of the present study was to determine whether instructional approaches involving the use of graphic organizers in conjunction with instruction of specific analytic reading skills would affect students' ability to solve story problems. This approach was compared to instruction in only analytic reading skills and no treatment (control). Based on the primary intent, the study tested the following hypotheses.

Hypotheses

One major null hypothesis was established to determine post-mean differences among the three groups. One minor hypothesis tested the post-mean differences between the two treatment groups. A second minor hypothesis measured the post-mean differences between the lower scoring treatment and the control groups. The third minor hypothesis was developed to discern whether differences in relationships existed between content subtests of the Story Problems Test for each group in the study. This chapter presents the results of the data analyses.

Major Hypothesis

There is no significant difference in the adjusted post-mean scores on tests of ability to solve story problems among the following groups: Students who receive instruction in utilization of graphic organizers in conjunction with analytic reading skills (Group 1); those who receive instruction in analytic reading skills (Group 2); and those who receive no treatment (Group 3).

The intent of this hypothesis was to determine if any significant difference in the ability to solve story problems occurred when sixth graders instructed in the utilization of graphic organizers and reading skills were compared to sixth graders who received instruction in only specific analytic reading skills, and to those who received no such instruction.

Presented in Figure 1 are the covariate, dependent, and adjusted dependent means for the three groups. Table 5 presents additional data analyses for the three groups indicating significance and source of variance between, as well as within, the three groups.

The analysis of covariance compared adjusted post-mean scores for sixth graders' ability to solve story problems and yielded an $\underline{F}$-ratio of 6.25 which was significant at the $\underline{p} < .05$ level. Thus, the post-mean difference between Treatment 1 and the control group was statistically significant and the null hypothesis rejected. In more general terms, instruction in specific analytic reading skills with graphic organizers, resulted in significantly higher scores on tests measuring the ability to solve story problems when compared to the absence of treatment.

Minor Hypotheses

The utilization of graphic organizers enables students to structure key concepts of text to facilitate understanding and recognize relationships in view of questions asked. Skill in the use of these elements influences the successful solution of story problems. The fundamental supposition of this experimental study was that the ability to read story problems is an important factor influencing students' success in solving story problems. Specific analytic reading skills also aid in the successful solution of story problems. The following minor hypotheses tested this assumption.

Minor Hypothesis One. No significant difference in the adjusted post-mean scores of tests of ability to solve story problems exists between students who receive instruction in utilization of graphic organizers in conjunction with reading skills (Group 1) and those who receive instruction in only reading skills (Group 2).

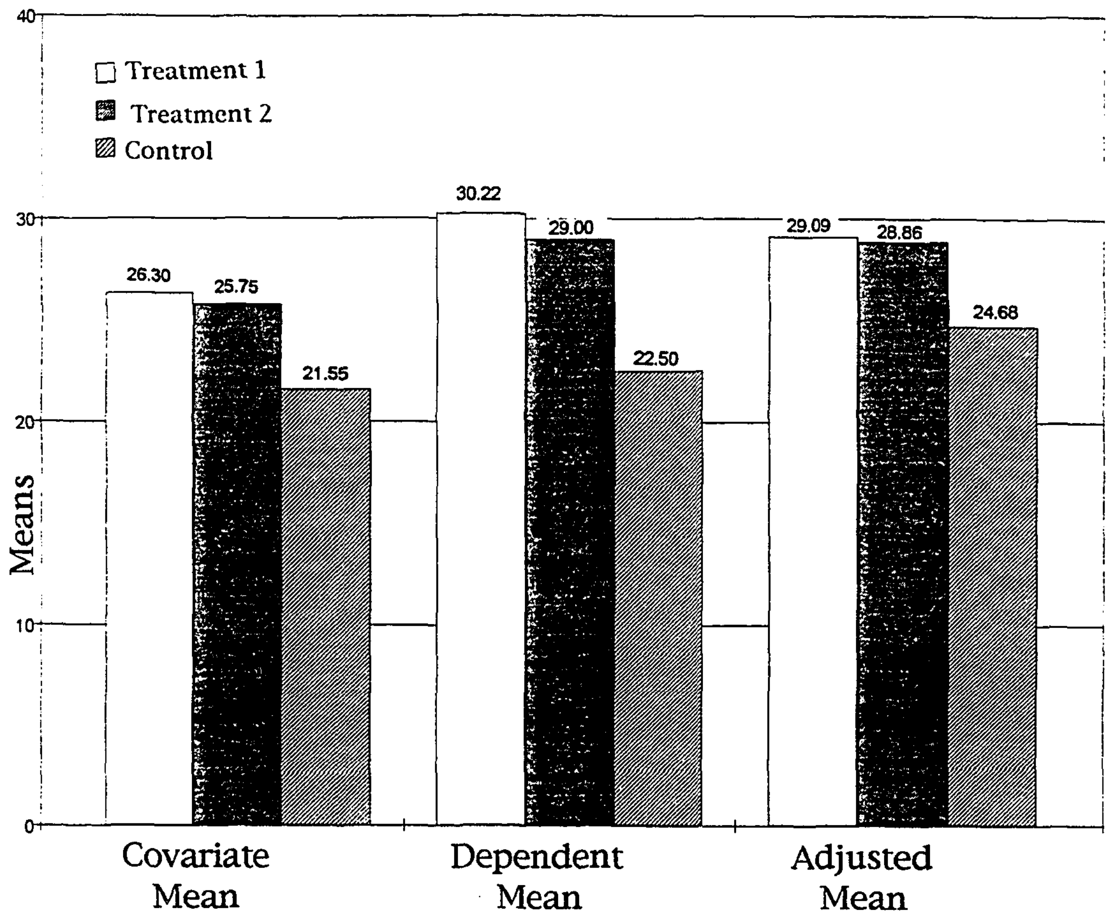


Figure 1

Problem Solving Mean Raw Scores for Treatment One (n = 23), Treatment Two (n = 24), and the Control Group (n = 20). (N = 67)

Table 5

Analysis of Covariance for Students in Treatment One, Two and the Control Group ($N = 67$)

Source	Adj. SS	df	Var. Est.	F
Between	211.40	2	105.70	6.25 *
Within	1065.49	63	16.91	
Total	1276.89	65		

* $p < .05$

It was the intent of this hypothesis to determine if any significant difference in problem solving achievement scores occurred when comparing sixth grade students instructed in the utilization of graphic organizers along with specific instruction in analytic reading skills to sixth-grade students instructed in specific instruction in analytic reading skills alone. The covariate, dependent, and adjusted dependent means for the problem solving abilities of students instructed in utilization of graphic organizers with specific analytic reading skills and those instructed in specific analytic reading skills alone appear in Figure 1.

Tukey's "honestly significant difference" (HSD) (Ferguson & Takane, 1989) method tested the adjusted mean scores of these two groups. The results of the Tukey HSD tests appear in Table 6. The comparison of adjusted mean scores for students who used graphic organizers in the solution of story problems (Group 1) and those who did not (Group 2), yielded a Q value of .94. Since the Q value of .94 is less than the critical Q value of 2.95 (Table L, Ferguson & Takane, 1989, pp. 570-571), the results were not statistically significant at the .05 level. Based on these results, the null hypothesis was accepted. In more general terms, instruction in the use of graphic organizers in addition to analytic reading skills and

Table 6

Tukey's Ad Hoc Comparison of Adjusted Mean Scores for Treatment One, Two and the Control Group (N = 67)

Group	Adj. Mean	Q
Group 1 (n = 23)	29.09	
		5.03 *
Group 3 (n = 20)	24.68	
Group 2 (n = 24)	28.86	
		4.08 *
Group 3 (n = 20)	24.68	
Group 1 (n = 23)	29.09	
		.94 ns
Group 2 (n = 24)	28.86	

* Note. Values of 4.02 and 2.95 are significant at the .01 and .05 levels, respectively.

instruction in analytic reading skills alone appeared to have similar achievement effect on the solution of story problems.

Minor Hypothesis Two. There is no significant difference in the adjusted mean scores on tests of ability to solve story problems between students who receive direct instruction in analytic reading (Group 2) and those who receive no such instruction (Group 3).

The intent of this hypothesis was to determine if any significant difference in problem solving achievement scores occurred when comparing sixth-grade students instructed in specific analytic reading skills to sixth-grade students who received no such instruction. The covariate, dependent, and adjusted dependent means for the problem solving ability of students instructed in specific analytic reading skills and those who received no such instruction appear in Figure 1.

The Tukey "honestly significant difference" (HSD) method (Ferguson & Takane, 1989) compared the adjusted mean scores of Group 2 (those who received instruction in analytic reading skills only) and Group 3 (those who received no special instruction). This procedure resulted in a Q value of 4.08. Since the Q value of 4.08 is greater than the critical Q value of 2.95 (Table L, Ferguson & Takane, 1989, pp. 570-571), the results were statistically significant at the .05 level and the hypothesis was rejected. In more general terms, instruction in analytic reading skills alone resulted in significantly higher scores of ability to solve story problems than did the absence of any special instruction.

Minor Hypothesis Three. There is no difference in the correlation coefficients between the specific reading abilities measured by the Story Problems Reading Subtest and the ability to solve story problems as measured by the Story Problems Solving Subtest, and between computation ability as measured by the Story Problems Computation Subtest and ability to solve story problems as measured by the Story Problems Solving Subtest.

The intent of this hypothesis was to measure the difference in the correlation between analytic reading ability and the ability to solve story problems and the correlation between the ability to perform straight mathematical computations and the ability to solve story problems. This hypothesis was tested by comparing the correlation coefficients of the three subtests of the Story Problems Test. Correlation coefficients for the Reading and Problem Solving Subtests and the Reading and Computation Subtests for all three groups as well as z-test results appear in Table 7. Differences between the correlation coefficients for the Reading and Problem Solving Subtests and Computation and Problem Solving Subtests for each of the three groups were tested for significance using

Fisher's z_r transformation formula (Ferguson & Takane, 1989). The differences between correlation coefficients for the subtests for Group 1, Group 2, or Group 3 were not significant. Therefore, Minor Hypothesis Three was accepted.

In more general terms, specific reading abilities are no more highly correlated with the ability to solve story problems than is computational ability.

Table 7

Significance of z - Test Comparisons of Correlation Coefficients for Reading and Solving Subtest Variables (N = 67)

Groups	Variables	Pearson's r	z	p
Group 1	Reading Subtest & Solving Subtest	.59	.45	ns
Group 1 n = 23	Computation Subtest & Solving Subtests	.49		
Group 2	Reading Subtest & Solving Subtest	.74	1.38	ns
Group 2 n = 24	Computation Subtest & Solving Subtest	.48		
Group 3	Reading Subtest & Solving Subtest	.74	1.39	ns
Group 3 n = 20	Computation Subtest Solving Subtest	.44		

Note. Values of 1.96 and 2.58 are significant at the .05 and .01 levels, respectively.

Chapter 5

Summary, Conclusions and Discussion, and Recommendations

The purpose of the present study was to determine the effects of instructional approaches on sixth graders' ability to solve mathematical story problems. The instructional approaches were of two levels. The first instructional approach was direct instruction in the utilization of graphic organizers in conjunction with specific instruction in analytic reading skills for the solution of story problems. The second approach was specific instruction in analytic reading skills alone for the solution of story problems. The absence of any instruction for the solution of story problems was the control.

A primary focus of mathematics education for the past two decades has been problem solving. Organizations whose fundamental concern is the improvement of teaching and learning in the content area of mathematics have published numerous documents stressing the importance of problem solving. Even though problem solving has been a key focal point of literature related to mathematics curriculum for the past decade, it remains a difficult aspect of mathematics for many students.

It has been posited that children are more likely to have language-related difficulties in the mathematics classroom than they experience anywhere else. Most teachers are unaware of the level of reading skills necessary for comprehending technical text. It can no longer be assumed by mathematics teachers that their students have acquired sufficient syntactic awareness and analytic reading skills to handle the complex and often convoluted text of story problems. McGregor (1990) proposed that learning how to read mathematical text needs to be part of the mathematics curriculum.

The present study focused on skills for improving students' ability to comprehend technical text. Knowledge of the difficulties children experience when processing mathematical language and recognition of the specialized skills necessary to comprehend mathematical text were targeted to improve sixth graders' achievement in the solution of story problems.

Experimental treatment lessons addressed the following areas:

1. Graphic organization of the text of story problems. Lessons for Experimental Group 1 presented the spatial arrangement of key concepts to promote comprehension of the text of story problems.

2. Analytic reading skills necessary to evaluate story problems. The investigator proposed techniques to both experimental groups for analyzing the text of story problems to

determine sufficient, insufficient, relevant, and irrelevant information.

3. Literal and inferential comprehension of content specific text. Lessons for both treatment groups developed strategies for defining vocabulary, identifying the main idea, and discovering relationships which exist in the text.

The basis for the study was the assumption that the abilities required for reading the content specific text of story problems differ from the abilities required for reading narrative text. The study examined the effect of specific analytic reading skills and the use of graphic organizers on sixth graders' ability to solve mathematical story problems.

The study measured the effects of special instruction in graphic organization and specific reading skills on students' achievement in the solution of story problems. The major hypothesis was as follows:

Sixth graders receiving specific instruction in the utilization of graphic organizers in conjunction with reading skills and sixth graders receiving instruction in only specific analytic reading skills will make greater achievement scores on tests of ability to solve story problems than sixth graders who receive no such instruction.

Three minor hypotheses were also made. Testing of the first minor hypothesis compared the achievement of sixth graders who received instruction in utilization of graphic organizers in conjunction with analytic reading skills to those who received instruction in only analytic reading skills. It was the intent of this hypothesis to determine if any significant difference in scores of problem solving ability occurred with sixth grade students instructed in the utilization of graphic organizers in conjunction with specific instruction in analytic reading skills. These students were compared to sixth-grade students instructed in specific analytic reading skills only.

The second minor hypothesis was tested by measuring the effect of instruction in analytic reading skills alone (the lower achieving treatment group). This effect was compared to the absence of such instruction. The intent of this comparison was to determine if any significant difference in scores of problem solving achievement occurred when students received instruction in analytic reading skills.

The fundamental supposition of this experimental study was that the ability to read story problems is an important factor influencing students' success in solving story problems. Specific analytic reading skills influence the successful solution of story problems. The third minor hypothesis was made based on these notions. Minor hypothesis three focused on the correlation between specific reading abilities and the ability to solve story problems, and the correlation between computational abilities and the ability to solve story problems.

Findings of the dissertation research are summarized in this chapter. Conclusions presented in the second section of the chapter are based on the research findings and discussed in relation to pertinent literature. The final section recommends practice and further research.

Summary

Sample Characteristics

The subjects for this experimental study were 67 sixth grade public school students. The sample included students from various socioeconomic levels and with a range of reading and mathematics abilities. The students were from three heterogeneously-grouped intact, sixth grade classes. Random selection assigned the three intact classes to the two treatment groups and the control group. Group 1 received Treatment One, Group 2 received Treatment Two, and Group 3 received no treatment.

Procedures

Students in the Experimental Group 1 (n = 23) received a series of 20 lessons over a four-month period in the use of graphic organizers and analytic reading skills. Experimental Group 2 (n = 24) received a series of 20 lessons in analytic reading skills only. The investigator taught both treatment groups three days per week. Each group received a minimum of ten hours of instruction during a nine-week period. This instruction was in addition to their regular reading and mathematics instruction.

The Control Group (Group 3) (n = 20) received no instruction in either graphic organizers or analytic reading skills during study hall. This group met with a regular classroom teacher in a study hall setting where they worked on varied activities (completing homework, library research, reading, etc.) There was no instruction in either reading or mathematics in the study hall environment for the duration of the study. The study hall was in addition to regular reading and mathematics instruction but in lieu of special instruction by the investigator.

Because the subjects of each group were not randomly assigned, an analysis of covariance (ANCOVA) adjusted the performance of the three groups on the posttest. Scores on the pretest were the covariate. The investigator administered the Story

Problems Test, as the pre and posttests. Before covariance analysis, the assumption of homogeneous regression coefficients was checked. Analysis of pretest scores revealed no significant difference ($p < .05$) in group means. A preliminary examination using Pearson's product-moment coefficient (see Table 4) indicated that a correlation existed between the pre and posttest measures. This permitted the use of the conventional analysis of covariance (ANCOVA).

The investigator administered the Story Problems Test at the conclusion of the study. To determine if differences between mean scores made on the posttests by students in the treatment groups were significant, a Tukey ad hoc comparison tested the data. As previously described, Tukey's "honestly significant difference" (HSD) method (Ferguson and Takane, 1989) is a powerful ad hoc comparison test that adjusts the level of significance to reduce the influence of chance when more than one comparison is involved. The .05 level was considered the point of statistical significance.

Findings

The findings of the study are summarized below:

1. There was a significant difference between the adjusted post-mean scores made on the total Story Problems Test by students who received instruction in graphic organizers and analytic

reading skills (Group 1) when compared to those who received no treatment (Group 3).

2. Students instructed in the use of graphic organizers in conjunction with analytic reading skills (Group 1) did not score significantly higher on the total Story Problems Test than students instructed in specific analytic reading skills alone (Group 2).

3. Students who received instruction in specific analytic reading skills only (Group 2) scored significantly higher on the total Story Problems Test than students who received no special instruction (Group 3).

4. The correlation between specific reading ability and the ability to solve story problems was not significantly different from the correlation between computational ability and the ability to solve story problems.

Conclusions

The following conclusions were reached as a result of the findings of this experimental study. These conclusions are discussed and related to pertinent literature.

Conclusion One

There was a significant difference in the problem solving abilities of students who received instruction in graphic organizers in conjunction with analytic reading skills, when compared to the students who did not receive either of these specific instructions. Specifically, there was a significant difference ($p < .05$) between Group 1 and Group 3 in post- mean scores made on the criterion measure (the Story Problems Test). The results support the conclusions of other studies (Berkowitz, 1986; Brasselton and Decker, 1994; and Estes, et al., 1969).

Evidence from studies by Berkowitz (1986), Brasselton and Decker (1994), and Estes, et al. (1969) indicated that the use of graphic organizers improved students' ability to comprehend expository text. Brasselton and Decker specifically reported that the use of graphic organizers enabled students to become more efficient at solving story problems. The results of the present study suggest significant improvement in sixth graders' ability to solve story problems when a graphic organizer is used in conjunction with analytic reading skills. When the effects of these instructional strategies were compared to the absence of either treatment, results indicate that instruction in how to use graphic organizers to structure the text of story problems with analytic reading skills improves students' ability to solve story problems.

Conclusion Two

Examination of raw scores on the Story Problems Test indicated that the group that received instruction in both graphic organizers and analytic reading skills had slightly greater achievement than the group that received instruction in analytic reading skills only. However, no significant difference ($p < .05$) was found in the adjusted mean scores. It appears that instruction in analytic reading skills alone had the same statistical effect on students' ability to solve story problems.

These findings are consistent with those of Hurad (1983) who found that training students how to graphically organize text did not result in significantly higher scores on independent learning ability. He suggested that instruction in utilization of graphic organizers may train students to become better graphic organizers, but may not increase their general learning from expository text.

Results of the present study found no significant differences between the problem solving ability of children who received instruction in graphic organizers in conjunction with reading skills when compared to those who received instruction in only reading skills. However, it should be noted that the treatment group of graphic organizer instruction in conjunction with analytic reading skills made slightly higher adjusted mean scores on the Story Problems Test than those who received only reading skills instruction. Based on these findings, the assumption should not be made that the graphic organizer instruction was not effective.

Careful analysis indicates that when given in conjunction with instruction in analytic reading skills and compared to no treatment, this approach is effective.

Conclusion Three

A significant difference in the ability to solve story problems resulted when comparing the group that received instruction in specific analytic reading skills only to the group that received no such instruction. These findings were consistent with other studies which found that instruction in reading skills is effective in improving students' ability to solve story problems (McNinch, 1982; Skrypa, 1979).

Even though the students who received instruction in specific analytic reading skills received slightly lower adjusted mean scores on the Story Problems Test when compared to those instructed in graphic organizers and analytic reading skills, they scored significantly higher than those who received no treatment. These findings support earlier studies by McNinch (1982) and Skrypa (1979), who found that instruction in reading skills is effective in improving students' ability to solve story problems.

McNinch (1982) found that even limited, direct instruction in vocabulary terms resulted in dramatic gains in students' comprehension. He noted that delivery of small amounts of planned vocabulary instruction increased test scores. McNinch's findings support earlier research done by Skrypa (1979). Results of that study suggested that teaching mathematics vocabulary led to improved scores, indicating a gain in not only vocabulary, but problem solving skills as well.

Research reviews by Reys, Suydam, & Lindquist (1994) indicated that merely the practice of solving story problems increased student's success. Callahan and Glennon (1975) supported these findings by concluding that students showed gains in problem solving ability when given problems to solve. Of particular interest was these authors' further finding which showed even greater gains when students were provided systematic instruction for the purpose of developing understanding. The present study supports Callahan and Glennon's latter results.

Conclusion Four

Both treatment groups made significantly higher adjusted post-mean scores than the control group. These findings suggest that the difference in achievement in solving story problems resulted from both treatments. Because these two treatments were given in addition to regular classroom instruction it should not be assumed that these treatments alone improved students' ability to solve story problems. However, because significantly more growth occurred than in the group that received no treatment, it cannot be argued that the improvement resulted solely from regular classroom instruction since the control group also had regular classroom instruction. Therefore, it appears that these treatments were effective when given in addition to regular classroom instruction in reading and mathematics.

Conclusion Five

There was no significant difference in the correlation coefficients between specific reading abilities as measured by the reading subtest of the Story Problems Test and the ability to solve story problems as measured by the solving subtest of the Story Problems Test when compared to the correlation coefficients between computation abilities as measured by the computation subtest of the Story Problems Test and the ability to solve story problems as measured by the solving subtest of the Story Problems Test. According to the tests used in the present study to measure these abilities, it appears that specific reading skills are no more closely related to the ability to solve story problems than are skills of computation. The ability to solve story problems seems to be a complex task requiring a combination of skills.

These findings contradict those of Muth (1984) who noted a more positive correlation between reading and solving abilities than computation and solving abilities. Conversely, these results support other research (Graebell & Anderson, 1992; Henney, 1970) which reported that students must have the prerequisite computational skills to benefit from instruction in reading skills for solving story problems. Henney (1970) also found no significant difference between correlation coefficients for reading and solving abilities and computation and problem solving abilities. She pointed out that computation is a factor, but only one of several that are critical to efficient problem solving.

Evidence from studies by Ballew and Cunningham (1982) and Muth (1984) targeted reading as the critical factor in solving story problems. When Muth looked at the relative importance of reading ability and computational ability to the solution of story problems, she found that both contributed; but, inadequate reading ability accounted for nearly twice as many errors as inadequate computational ability. Ballew and Cunningham (1982) found that almost one third of a group of sixth graders identified reading as their difficulty in solving story problems. The present study correlated only total subtest scores for reading and computation to total subtest scores for solving. No item analysis determined the variance in correct answers.

The results of the correlation analyses in the present study point to the internal consistency of the Story Problems Test. The investigator designed this instrument for use as the criterion measure of achievement in the solution of story problems. The test was developed because there was not available a commercially standardized instrument designed to measure the elements that were the focus of the present study. Based on the results of these correlation analyses, it can be assumed that the Story Problems Test is suitable for use by classroom teachers interested in measuring these abilities.

In general, the findings of the present study appear to support the notion that instruction in specific analytic reading skills (with or without graphic organizers) improves students' ability to solve story problems.

Implications and Recommendations

The results of the present study and related literature suggest several implications and recommendations.

Implications

Based on the findings of this research, it appears that instruction in analytic reading skills with or without instruction in graphic organizers has a positive effect on students' abilities to solve story problems when given in addition to regular instruction in reading and mathematics. The results of the study indicate that neither treatment -- instruction in utilization of graphic organizers in conjunction with analytic reading skills nor instruction in specific analytic reading skills -- was more effective than the other in improving students' ability to solve story problems.

Regular classroom teachers may use either level of instructional approach to strengthen students' ability to solve story problems. Once students learn the necessary computational skills required to solve a particular genre of story problems, it is apparent that skills in graphic organization and analytic reading improve story problem solving ability. Employing reading skills and using graphic organizers to structure information helps students to recognize relations which exist as well as identify and understand vocabulary. It helps them to summarize the main idea and restate questions in the problem. These techniques also enable students to note important details, distinguish between problems where information is insufficient and problems which contain information not relevant to the solution. Further benefits include reading to note sequence, predicting outcomes, and formulating a sentence which answers the question in the problem. The combination of all these skills was associated with achievement in students' ability to solve story problems.

Instruction in analytic reading skills alone when compared to the absence of graphic-organizer instruction resulted in significant gains in students' ability to solve story problems. Teachers need to be aware of these results. They must not assume that students automatically transfer the analytic reading skills taught in the reading classroom to the mathematics classroom. Efforts should be made to provide and differentiate technical content reading instruction in the mathematics classroom, just as in the reading classroom, to accommodate varying levels of reading ability. Specific reading skills much like those employed in Language Experience, Directed Reading Activity, and PQ4R, even without the use of graphic organizers, appear to enable students to become more efficient problem solvers.

The absence of a significant difference in correlation coefficients between reading and problem solving abilities and computation and problem solving abilities seemed to reinforce the notion that solving story problems is a complex task. Success in solving story problems is most likely a combination of many abilities, all of which were not measured by the study. However, instruction in analytic reading skills applied to the text of story problems does positively affect the degree to which students' experience achievement. Teachers need not wait until students master computation skills before challenging them to solve story problems. Partial credit may be awarded students who use the correct approach and perform the correct operation --even if they make a calculation error. Students need to be exposed to the strategies for reading and organizing the information in story problems as operations and algorithms are developed. The crucial role that reading plays in solving story problems must not be overlooked.

Recommendations

The findings of the present study support the results of some previous research and the notion that reading plays a vital role in the solution of story problems. The investigator recommends further research to ascertain the degree to which reading impacts students' ability to solve story problems. A longitudinal study would determine the long-term effects of the special instruction.

The results of the present study point to the positive impact that instruction in specific analytic reading skills with or without instruction in graphic organizers, in addition to regular instruction in reading and mathematics, had on students' ability to solve story problems. The need exists for a study to measure the effectiveness of this instruction in the context of regular mathematics instruction.

A Math, Science, Computer Magnet School served as the site for the present study. Although there is no special aptitude for mathematics required for admission to this school, it is certainly an emphasis of the school. The school's stress on mathematics and perhaps computation may have confounded the results. A replication of the present study in a non-magnet or setting that emphasizes other disciplines might reveal a significant difference between reading abilities and problem solving abilities and computation and problem solving abilities.

The investigator delivered the instruction for the treatment groups in the study. As mentioned in the limitations of the study, the investigator's enthusiasm for the project and eagerness for the subjects to improve may have influenced the instruction, confounding the results. Although every effort was made to control for this factor, it is recommended that the study be repeated using the regular classroom teacher to instruct the treatment groups.

The sixth grade was chosen for the present study because it represents a midpoint in the years when students focus on story problems. Perhaps many strategies and "tricks" for solving story problems have already been deeply implanted by the time students reach sixth grade. For this reason, a similar study is suggested at a lower grade level.

The Story Problems Test used as the criterion measure for the study was found to be a reliable instrument for measuring students' ability to solve story problems. Another study with the same treatments using qualitative methodology would allow the investigator to look at behaviors other than those measured by the Story Problems Test. Many children suffer from test anxiety. A qualitative study would control for this factor.

Although every effort should be made to differentiate instruction to meet the individual needs of students, time constraints permitted only limited provisions for individual differences during the treatment lessons. A qualitative study conducted in the context of the mathematics classroom would allow variance in type, amount, and rate of treatment administration.

As classroom teachers recognize the critical role which analytic reading skills play in their students' abilities to solve story problems, the need grows for more effective preparation in content reading courses. Content reading instructors must acknowledge and define their part so that all teachers become teachers of reading. It is the responsibility of these preparatory courses to emphasize the vital role that reading plays in mathematics problem solving and clarify the teachers' role in teaching students to read mathematics.

As alluded to in the introduction to this document, an unfavorable attitude toward story problems seems pervasive. This cynicism appears to be shared by students, parents, and many educators. Perhaps research to measure the influence this attitude has on students' ability to solve story problems may prescribe possible intervention.

References

Aiken, L. (1971). Verbal factors in mathematics learning: A review of research. Journal of Research in Mathematics 2.

Ballew, H. & Cunningham, J. (1982). Diagnosing strengths and weaknesses of sixth-grade students in solving word problems. Journal of Research in Mathematics Education 13, 202-210.

Balow, I. (1964). Reading and computation ability as determinants of problem solving. Arithmetic Teacher, 11, 18-22.

Barron, R.F., & Cooper, R. (1973). Effects of advance organizers and grade level upon information acquisition from an instructional level general science passage. In P.L. Nacke (Ed.), Diversity in mature reading: Theory and research. Clemson, SD: National Reading Conference.

Berkowitz, S.J. (1989). Effects of instruction in text organization on sixth-grade students memory for expository reading. Reading Research Quarterly, 21, 161-178.

Blohm. P., & Wiebe, J. (1980). Effects of representation and organizational features of text on success in mathematical problem-solving. Paper presented at the annual meeting of the American Reading Conference, Sarasota, FL.

Bolding, J. (1984). Statistics with finesse [Computer software]. Fayetteville, AR: University of Arkansas.

Braselton, S. & Decker, B. (1994). Using graphic organizers to improve the reading of mathematics. The Reading Teacher, 48(3), 276-281.

Brennan A. & Dunlap, W. (1985). What are the prime factors of reading mathematics? Reading Improvement 22, 152-159.

Call, R. & Wiggin, N. (1966). Reading and mathematics. Mathematics Teacher, 149-157.

Callahan, L. & Glennon V. (1975). Elementary school mathematics: A guide to current research (4th ed). Washington, DC: Association for Supervision and Curriculum Development.

Carpenter, T., Corbitt, M.K., Kepner, H., Jr., Lindquist, M. & Reys, R. (1980). Solving verbal problems: Results and implications from national assessment. Arithmetic Teacher, 28(1), 8-12.

Cohen, S. & Stover, G. (1981). Effects of teaching sixth-grade students to modify format variable of math word problems. Reading Research Quarterly 16, 175-200.

Corwin, R. & Price, S. (1995). The changing look of mathematics instruction. Streamlined Seminar 13(5). National Association of Elementary School Principals. Alexandria, VA.

Culyer, R. (1988). Reading and mathematics go hand in hand. Reading Improvement, 25, 189-195.

Curry, J. (1989). The role of reading instruction in mathematics. In Flood, J. & Farren, (Eds.) Content area reading and learning: Instructional strategies. Englewood Cliffs, NJ: Prentice-Hall.

Estes, T.H., Mills, D.C. & Barron, R. (1969). Three methods of introducing student reading-learning task in two content subjects. In H.L. Herber & P.L. Sanders, (Eds.), Research in reading in the content areas; First-year report. Syracuse, NY: Syracuse University Press.

Earle, R. (1976). Teaching reading and mathematics. Newark, DE: International reading Association.

Erlwanger, S.J. (1974). Case studies of children's conception of mathematics. Doctoral Dissertation, University of Illinois, Urbana-Champaigne.

Ferguson, A. & Fairburn, J. (1985). Language experience for problem solving in mathematics. The Reading Teacher 38, 504-507.

Ferguson, G. A. & Takane, Y. (1989). Statistical analysis in psychology and education. New York, NY: McGraw-Hill.

Garofalo, J. & Lester F., Jr. (1985). Metacognition, cognitive monitoring and mathematical performance. Journal for Research in Mathematics Education, 16, 163-176.

Glass , G. & Hopkins, K. (1984). Statistical methods in education and psychology. Englewood Cliffs, N J: Prentice Hall.

Gleason, M., Silbert, J., & Carnine, D., (1990). Math story problems. In J. Silbert, D. Carnine, & M. Stein (Eds.) Direct instruction mathematics. Columbus, OH: Merrill.

Greabell, L. & Anderson, N. (1992). Applying strategies from the directed reading activity to a directed mathematics activity. School Science and Mathematics 92(3), 143-144.

Guri-Rozenbilt, S. (1989). Effects of a tree diagram on students' comprehension of main ideas in an expository text with multiple themes. Reading Research Quarterly, 24, 236-247.

Harris, T. & Hodges, R. (Eds.) (1995). The literacy dictionary: The vocabulary of reading and writing. Newark, DL: International Reading Association.

Henney, M. (1970, May). Improving mathematics verbal problem solving ability through reading instruction. Paper presented at the conference of the International Reading Association, Anaheim, CA: (ERIC Document Reproduction Service ED 044 241).

Hurad, S.D. (1983) The effect of graphic postorganier training on learning from text (Doctoral dissertation, University of Connecticut, 1983). Dissertation Abstracts International, 44, 477 A.

Jerman, M. & Mirman, C. (1974). Linguistic and computational variables in problem solving in elementary mathematics. Educational Studies in Mathematics, 5.

Jongsma, K. (1991). Mathematics and reading. The Reading Teacher 44(6), 442-442.

Kouba, V. , Brown, C., Carpenter, T., Lindquist, M., Silver, E., & Swafford, J. (1988). Results of the fourth NAEP assessment of mathematics: Numbers, operations, and word problems. Arithmetic Teacher, 35(8), 14-19.

Kroll, D. & Miller, T. (1993). Insights from research on mathematical problem solving in the middle grades. In Owens, D.T. (Ed.), Research ideas for the classroom: Middle grades mathematics. (pp. 58-77). Reston, VA: National Council of Teachers of Mathematics.

Krulik, S., (1980). To read or not to read that is the question! Mathematics Teacher, 248-252.

Krutetski, J. (1976). The psychology of mathematical abilities in school children. Chicago, IL: University of Chicago Press.

Laborde, C. (1992). Students' reading and writing of mathematics. In M. Quigley (Ed.), Proceedings of the Annual Meeting. (pp. 9-23) Canadian Mathematics Education Study Group. Fredericton, New Brunswick, Canada (ERIC Document Reproduction Service No. ED 350 161)

Linn R. & Gronlund, N. (1995). Measurement and assessment in teaching. (7th ed.) Englewood Cliffs, NJ: Prentice-Hall

MacGregor, M. (1990). Reading and writing in mathematics. In Bickmore-Brand, J. (Ed.), Language in mathematics (pp. 100-109). Portsmouth, NH: Heinemann.

Maffei, A. (1973). Reading analysis in mathematics. Journal of Reading, 16, 325-326.

Manzo, A. (1975). The math student/the math teacher/the math problem. Paper presented at the annual meeting of the Missouri Council of Teachers of Mathematics. (ERIC Document Reproduction Service No. ED 114 767)

McCabe, P. (1981). The effect upon comprehension of mathematics material repatterned on the basis of oral language. Reading World, 21(2), 146-154.

McNinch, G. (Ed.) (1982) Reading in the disciplines: Second yearbook of the American Reading Forum. ERIC Document Reproduction Service No. ED 225 141)

Moore, D. W. & Readence, J. E. (1980). A meta-analysis of the effect of graphic organizers on learning from text. In M.L. Kamil, & A.J. Moe (Eds.), Perspectives in reading research and instruction. Twenty-ninth Yearbook of The National Reading Conference.

Moore, D.W., & Readence, J.E. (1984). A quantitative and qualitative review of graphic organizer research. Journal of Educational Research, 78(1), 11-17.

Moyer, J., Moyer, M., Sowder, L., & Threadgill-Sowder, J. (1984). Story problem formats: Drawn versus telegraphic. Journal for Research in Mathematics Education, 15(1), 64-68

Moyer, J., Sowder, L., Threadgill-Sowder, J., & Moyer, M. (1984). Story problem formats: Drawn versus verbal versus telegraphic. Journal for Research in Mathematics Education, 15(5), 342-351.

Murray, J. (1993). Children reading mathematics. Newcastle Upon Tyne: Athenaeum Press.

Muth, D. (1984). Solving arithmetic word problems: Role of reading and computational skills. Journal of Educational Psychology, 76, 205-210.

Muth, D. (1993). Reading in mathematics: Middle school mathematics teachers' beliefs and practices. Reading Research and Instruction, 32(2),76-83.

Mullis, I. V., S, Dossey, J. A., Owen, E. H., & Phillips, G. W. (1993). NAEP 1992: Mathematics report card for the nation and the states. Washington, D. C.; National Center for Education Statistics.

National Council of Teachers of Mathematics (1980). An Agenda for Action: Recommendations for school mathematics of the 1980's. Reston,VA:National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (1991). Professional standards for teaching mathematics. Reston,VA: National Council of Teachers of Mathematics.

Newman, M. A. (1977). An analysis of sixth-grade pupils' errors on written mathematical tasks. Research in Mathematics Education in Australia, 1 239-258.

O'Brien, R. & Casey, S. (1983). Children learning multiplication: Part I. School science and mathematics, 83(3), 246-251.

O'Mara, D. (1981). The process of reading mathematics. Journal of Reading 25, 22-29.

Popham, J. (1993). Educational evaluation. Needham, Heights, MA: Allyn and Bacon

Ratekin, N., Simpson, M., Alvermann, D., & Dishner, E. (1985). Why content teachers resist reading instruction. Journal of Reading 28(5), 432-437.

Reys, R. Suydam, M. & Lindquist, M.M. (1994). Helping children learn mathematics. Needham Heights, MA: Allyn and Bacon.

Robinson, F. (1946). Effective study. New York: Harper & Row.

Romberg, T. & Carpenter, T.(1986). Research on teaching and learning mathematics: Two disciplines of scientific inquiry. In Wittrock, M. (Ed), Handbook of research on teaching (pp. 850-873). New York,NY: Macmillan.

Rubens, P. (1980). Decoding the calculus: Double jeopardy in readability. Paper presented at the annual convention of the International Reading Association. St. Louis, MO: (ERIC Document Reproduction Service
ED 188 120).

Siegel, M. Borasi, R., & Smith, C. (1989). A critical review of reading in mathematics instruction: The need for a new synthesis. Reproduction No. CS 009 446 Rochester, NY: University of Rochester. (ERIC Document Reproduction Service No. ED 301 863).

Silver, E. (1979). Student perceptions of relatedness among mathematical verbal problems. Journal of Research in Mathematics Education, 10, 195-210.

Singer, H. & Donlan, D. (1989). Reading and learning from text. (2nd ed.). Hillsdale, NJ: Erlbaum.

Simmons, D.C., Griffin, C.C. & Kameenui, E.J. (1988). Effects of teacher-constructed pre- and post-graphic organizer instruction on sixth-grade science students' comprehension and recall. Journal of Educational Research, 82(1).

Skrypa, A. (1979). Effects of mathematical vocabulary training on problem-solving abilities of third and fourth graders. (Doctoral dissertation, Rutgers University, 1979. (ERIC Document Reproduction Service No. ED 172 169)

Sowder, L. (1988). Children's solutions to story problems. Journal of Mathematical Behavior, 7(3), 227-238.

Sowder, J., & Sowder, L. (1989). Story problems and students' strategies. Arithmetic Teacher, 36(9), 25-26.

Stockdale, S. R. (1989). A study of the relationship between verbal cue words and elementary children's ability to solve word problems. Unpublished manuscript.

Stockdale, S. R. (1991). A study of frequency of selected cue words in elementary textbook word problems. School Science and Mathematics 91(1), 15-21.

Szetela, W. & Nicol, C. (1992). Evaluating problem solving in mathematics. Educational Leadership, 42-45.

Suydam, M. (1982). Update on research on problem solving : Implication for classroom teaching. Arithmetic Teacher, 29, 56-60.

Tierney, R. Readence, E., & Dishner, E. (1990). Reading strategies and practices: A compendium. Boston, MA: Allyn & Bacon.

Thomas, D. (1988). Reading and reasoning skills for math problem solvers. Journal of Reading, 244-249.

Thomas, E. & Robinson, H. (1972). Improving reading in every class. (Abridged ed.). Boston: Allyn & Bacon.

Appendix A
Story Problems Test

Computation Subtest

Perform the necessary calculations to complete the following exercises on the scratch paper provided. Select the best response from the choices provided and write the letter of that response

1. $\begin{array}{r} 1948 \\ \underline{+\ 12} \end{array}$

   a) 1960
   b) 1936
   c) 23,376
   d) 748

2. Which of the following is the most true statement:

   a) 987 is $<$ 1200
   b) 987 is $>$ 1200
   c) 987 is $=$ 1200
   d) 987 is $\neq$ 1200
   e) a and d

3. $\begin{array}{r} 4000 \\ \underline{-3109} \end{array}$

   a) 1109
   b) 7109
   c) 891
   d) 801

4. $\begin{array}{r} 3206 \\ \underline{+981} \end{array}$

   a) 41,187
   b) 4187
   c) 2,225
   d) 6,224

5. $\begin{array}{r} 14{,}000 \\ \underline{-2{,}250} \end{array}$

   a) 11,750
   b) 12,250
   c) 2,250
   d) 16,250

6. 32 x 6
   a) 1812
   b) 362
   c) 30
   d) 192

7. 28 x 5
   a) 60
   b) 140
   c) 50
   d) 108

8. 87 -- 7
   a) 1.242
   b) 12 R
   c) 12 R 3
   d) 1,242

9. $ 1.00 -- 5
   a) $ 2
   b) $ .05
   c) $ .20
   d) $2.00

10. 1188 -- 33
   a) 39204
   b) 39.204
   c) 36
   d) 3.600

Reading Subtest

Read the story problems below very carefully. Select the letter of the response that best answers the question about the story problem.

11. Sue scored more goals than Pam. Pam scored more goals than Amy. Amy scored more goals than Beth. Who scored the most goals? The fewest goals?

    This problem is about:
    a) something to eat.
    b) something to wear.
    c) something scored in a soccer game.
    d) something only girls play.

12. Felicia's baseball cards are worth $ 987. Hale's baseball cards are worth$ 1200. Who has cards that are worth more? How much more?

    This problem is about:
    a) who has the most baseball cards.
    b) who has the least valuable baseball cards.
    c) who is wealthier, Felicia or Hale.
    d) who has the most valuable baseball cards.

13. African elephants weigh as much as 14,000 pounds. Asian elephants weigh 2250 pounds less than that. How much do Asian elephants weigh?

    This problem is about:
    a) an African safari.
    b) the diet of Asian elephants.
    c) the difference in weight of African and Asian elephants.
    d) a trip to the zoo.

14. The first bathyscaphe was tested in 1948. The record ocean descent was made in a bathyscaphe 12 years later. In what year was this descent made?

    This problem does NOT tell:
    a) when the bathyscaphe was tested.
    b) what a bathyscaphe is.
    c) when the record ocean descent was made.
    d) how many years after the bathyscaphe was tested the record descent was made.

15. Sally went to the store to buy some apples. She could get 5 apples for $ 1.00. How much did she have to pay for the apples which she bought?

    To solve this problem I do NOT need to know:
    a) how many apples Sally could get for $ 1.00.
    b) how much money Sally had.
    c) how many apples Sally bought.
    d) how much each apple cost.

16. Washington School wanted to recycle paper this year. They could get $500.00 for 8000 pounds of paper. How much money did they make this year?

    To solve this problem I do NOT need to know:
    a) how much they could get per pound for paper.
    b) how many pounds they recycled during the course of the year.
    c) how many pounds of paper they used during the year.
    d) how many pounds of paper would bring $500.

17. In a fifth grade class of 33 students, 825 cans were collected the first day and 363 cans the second day. Find the average number of cans that each fifth grader collected.

Which is NOT true about this problem?
a) more than twice as many cans were collected the first day.
b) 363 is more than half of 825.
c) more cans were collected on the first day than the second day.
d) fewer cans were collected on the second day than the first day.

18. The Nile River is 3206 miles longer than the Ohio River. The Ohio River is 3019 miles shorter than the Amazon River. The Amazon River is 4000 miles long. The Mississippi River is 3,710 miles long. How long is the Nile River?

Which is NOT true about this problem?
a) The Amazon River is longer than the Nile River.
b) The Nile River is longer than the Ohio River.
c) The Ohio River is shorter than the Nile River.
d) The Amazon River is shorter than the Nile River.

19. We are planning a banquet for approximately 118 people. There are 120 chairs in the banquet hall. There are 10 chairs at each table. How many tables are there?

Which is NOT true about this problem?
a) there are more chairs than tables.
b) there are 12 times as many chairs as tables.
c) there are more tables than chairs.
d) there are 12 chairs per table.

20. Mrs. Adams bought a ream of notebook paper for her five children to use at school. There were 500 sheets in the ream. It cost $ 3.00. If the children shared the paper equally, how many sheets did each child get?

To solve this problem I need to know:
a) what the paper would be used for.
b) how many sheets of paper the children had to share.
c) how much the whole ream of paper cost.
d) how much each sheet of paper cost.

21. Julie took a test and had 4 answers wrong. To pass the test she needed to have at least 26 answers correct. Did Julie pass the test?

To solve this problem I need to know:
a) how many answers were left blank.
b) in what class the test was given.
c) how many answers Julie guessed correctly.
d) how many questions were on the test.

22. Walter's science class is involved in a 6 week project. For this project he has collected over the past 3 weeks, 93 moths for one case, 26 butterflies for another case, 100 fire ants for a third case, and 69 various leaves for another case. What is the average number of insects that Walter has collected per week?

I know from this problem that:
a) Walter enjoys his science class.
b) butterflies are more difficult to catch than moths.
c) science projects are fun.
d) Walter is a good student.

23. 87 scouts went on a canoeing trip. The scouts ate dinner in groups of 7 each. The rest ate with the scoutmaster. How many ate with the scoutmaster?

This problem asks me to:
a) find out how many groups of 7 scouts ate dinner
b) find the number who did not eat in groups of 7
c) compare the number of scouts who ate in groups of 7 with the number who ate with the scoutmaster.
d) find out how many scouts ate in groups of 7

24. Mrs. Wolfe's science class planted 80 evergreen trees in the courtyard at Clark School. They planted the trees in five different sections of the courtyard. There were the same number of trees in each section. How many trees were in one section?

This problem tells that:
a) the trees would be planted in five separate areas in the courtyard.
b) the trees would be planted with five to each row.
c) there were to be five different kinds of trees planted.
d) the trees would be planted at five different times.

25. There are 6 classrooms in a school which have 32 children each. There are 5 rooms at that school which have 28 children. How many children attend that school?

I do NOT need to find out:
a) how many children are in the 11 rooms.
b) how many children are in 5 of the rooms.
c) how many children are in six of the rooms.
d) how many boys are in the rooms

Solving Subtest

Read the story problems below very carefully. Select the letter of the response that best solves the story problem.

26. Sue scored more goals than Pam. Pam scored more goals than Amy. Amy scored more goals than Beth. Who scored the most goals? The fewest goals?

    a) Sue and Pam scored more goals than Amy and Beth.
    b) Sue scored the most goals; Pam scored the fewest.
    c) Pam scored the most goals; Beth scored the fewest.
    d) Sue scored the most goals; Amy scored the fewest.

27. Felicia's baseball cards are worth \$ 987. Hale's baseball cards are worth \$ 1200. Who has cards that are worth more? How much more?

    a) Felicia's cards are worth more than Hale's by\$ 213.00.
    b) Felicia's cards are worth more than Hale's by \$ 2,187.00.
    c) Hale's cards are worth more than Felicia's by \$ 213.00
    d) Because of personal preferences, both collections are worth the same.

28. African elephants weigh as much as 14,000 pounds. Asian elephants weigh 2250 pounds less than that. How much do Asian elephants weigh?

    a) Asian elephants weigh 16,250 pounds more than African elephants.
    b) Asian elephants weigh 2,250 pounds less than African elephants.
    c) Asian elephants weigh 11,750 pounds.
    d) Asian elephants weigh 11,750 pounds less than African elephants.

29. The first bathyscaphe was tested in 1948. The record ocean descent was made in a bathyscaphe 12 years later. In what year was this descent made?

    a) 1936 was the year the bathyscaphe was first tested.
    b) 1936 was the year the first descent was made in a bathyscaphe.
    c) 1960 was the year the first descent was made in a bathyscaphe.
    d) 1950 was the year the first descent was made in a bathyscaphe.

30. Sally went to the store to buy some apples. She could get 5 apples for $ 1.00. How much did she have to pay for the apples which she bought?

    a) $ 5.00
    b) $ .25
    c) $ .20
    d) not able to answer

31. Washington School wanted to recycle paper this year. They could get $500.00 for 8000 pounds of paper. How much money did they make this year?

    a) approximately 6 cents per pound
    b) approximately $ 4,000,000.
    c) approximately $ 7,500.
    d) it is impossible to tell

32. In a fifth grade class of 33 students, 825 cans were collected the first day and 363 cans the second day. Find the average number of cans that each fifth grader collected.

a) 1,188 cans were collected
b) 33 is the average number of cans collected
c) 36 is the average number of cans each 5th grader collected
d) unable to answer

33. The Nile River is 3206 miles longer than the Ohio River. The Ohio River is 3019 miles shorter than the Amazon River. The Amazon River is 4000 miles long. The Mississippi River is 3,710 miles long. How long is the Nile River.

a) the Nile River is 6225 miles long
b) the Nile River is 4,187 miles long
c) the Nile River is 7,019 miles long
d) the Nile River is 981 miles long.

34. We are planning a banquet for approximately 118 people. There are 120 chairs in the banquet hall. There are 10 chairs at each table. How many tables are there?

a) 130 tables
b) 110 tables
c) 12 tables
d) 10 tables

35. Mrs. Adams bought a ream of notebook paper for her five children to use at school. There were 500 sheets in the ream. It cost $ 3.00. If the children shared the paper equally, how many sheets did each child get?

a) 167 sheets
b) 100 sheets
c) .0006 per sheet
d) not enough information to answer

36. Julie took a test and had 4 answers wrong. To pass the test she needed to have at least 26 answers correct. Did Julie pass the test?

   a) yes
   b) no
   c) barely
   d) there is not enough information to answer

37. Walter's science class is involved in a 6 week project. For this project he has collected over the past 3 weeks, 93 moths for one case, 26 butterflies for another case 100 fire ants for a third case, and 69 various leaves for another case. What is the average number of insects that Walter has collected per week?

   a) 64 insects
   b) 73 insects
   c) 96 insects
   d) none of these

38. 87 scouts went on a canoeing trip. The scouts ate dinner in groups of 7 each. The rest ate with the scoutmaster. How many ate with the scoutmaster?

   a) 12 scouts
   b) 609 scouts
   c) 7 scouts
   d) 3 scouts

39. Mrs. Wolfe's science class planted 80 evergreen trees in the courtyard at Clark School. They planted the trees in five different sections of the courtyard. There were the same number of trees in each section. How many trees were in one section?

    a) 16 trees
    b) 5 sections
    c) 400 trees
    d) 80 trees

40. There are 6 classrooms in a school which have 32 children each. There are 5 rooms at that school which have 28 children. How many children attend that school?

    a) 192 children
    b) 140 children
    c) 332 children
    d) 60 children

Appendix B
Overview of Lessons for Treatment One

Lesson 1 -- Story problems with simple vocabulary and only relevant information requiring one-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, identifying the question, and inferring the operation.

Lesson 2 -- Story problems with more difficult vocabulary and only relevant information requiring one-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, identifying the question,and inferring the operation.

Lesson 3 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, main idea, identifying the question, and inferring the operation.

Lesson 4 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, and inferring operations.

Lesson 5 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, and inferring operations.

Lesson 6 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant information, and inferring operations.

Lesson 7 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 8 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant information, and inferring the operation.

Lesson 9 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 10 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Investigator presented a post-reading, teacher-constructed graphic organizer. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 11 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Students constructed their own graphic organizers. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 12 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one and two-step solutions were presented. Students constructed their own graphic organizers. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operations.

Lesson 13 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one and two-step solutions were presented. Students constructed their own graphic organizers. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operations.

Lesson 14 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one and two-step solutions were presented. Students constructed their own graphic organizers. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 15 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one-step solutions were presented.
Investigator presented teacher-constructed graphic organizer.
Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 16 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one-step solutions were presented.
Students constructed their own graphic organizers.
Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 17 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one-step solutions were presented.
Students constructed their own graphic organizers.
Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 18 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one and two-step solutions were presented.
Students constructed their own graphic organizers.
Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 19 -- Story problems with more difficult vocabulary and insufficient relevant information and irrelevant information requiring one and two-step solutions were presented. Students constructed their own graphic organizers.
Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, distinguishing between relevant and irrelevant information, identifying and providing relevant information, and inferring the operations.

Lesson 20 -- Story problems with more difficult vocabulary and insufficient relevant information and irrelevant information requiring one and two-step solutions were presented. Students constructed their own graphic organizers.
Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, distinguishing between relevant and irrelevant information, identifying and providing relevant information, and inferring the operations.

Appendix C
Overview of Lessons for Treatment Two

Lesson 1 -- Story problems with simple vocabulary and only relevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, identifying the question, and inferring the operation.

Lesson 2 -- Story problems with more difficult vocabulary and only relevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, identifying the question, and inferring the operation.

Lesson 3 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, main idea, identifying the question, and inferring operations.

Lesson 4 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, and inferring operations.

Lesson 5 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, and inferring operations.

Lesson 6 -- Story problems with more difficult vocabulary and only relevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant information, and inferring operations.

Lesson 7 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 8 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant information, and inferring the operation.

Lesson 9 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 10 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operation.

Lesson 11 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information and inferring the operation.

Lesson 12 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operations.

Lesson 13 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operations.

Lesson 14 -- Story problems with more difficult vocabulary and relevant and irrelevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying relevant and irrelevant information, and inferring the operations.

Lesson 15 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 16 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 17 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operation.

Lesson 18 -- Story problems with more difficult vocabulary and insufficient relevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, identifying and providing relevant information, and inferring the operations.

Lesson 19 -- Story problems with more difficult vocabulary and insufficient relevant information and irrelevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, distinguishing between relevant and irrelevant information, identifying and providing relevant information and inferring the operations.

Lesson 20 -- Story problems with more difficult vocabulary and insufficient relevant information and irrelevant information requiring one and two-step solutions were presented. Reading skills focused on vocabulary development, paraphrasing the main idea, restating the problem question, distinguishing between relevant and irrelevant information, identifying and providing relevant information and inferring the operations.

Appendix D

Format of Lesson Plan for Treatments

Introduction: (5 minutes)

Brief review of previous skill.
Statement of the purpose of the lesson.
Motivation

Learning Activities: (25 minutes)

1. Introduce, demonstrate, and discuss new skill.(5 min.)
    a. identify and define unfamiliar vocabulary
    b. summarize the main idea
    c. restate the question
    d. identify needed information
    c. isolate any extraneous information
    e. determine the needed operation
    f. perform computations
    g. write a solution sentence
    h. check

2. Guide practice of new skill as students solve one story problem with the investigator. (5 minutes)
3. Students work independently on 3-4 story problems (15 minutes)

Monitoring:

Move about the room interacting with each student giving specific, corrective feedback.

Students correct any mistakes.

Collect the papers to be placed in the students' portfolio.

Appendix E
Story Problem Graphic Organizer

Vocabulary

1.____________________

2.____________________

3.____________________

4.____________________

Main Idea:

Question:

Important Facts:

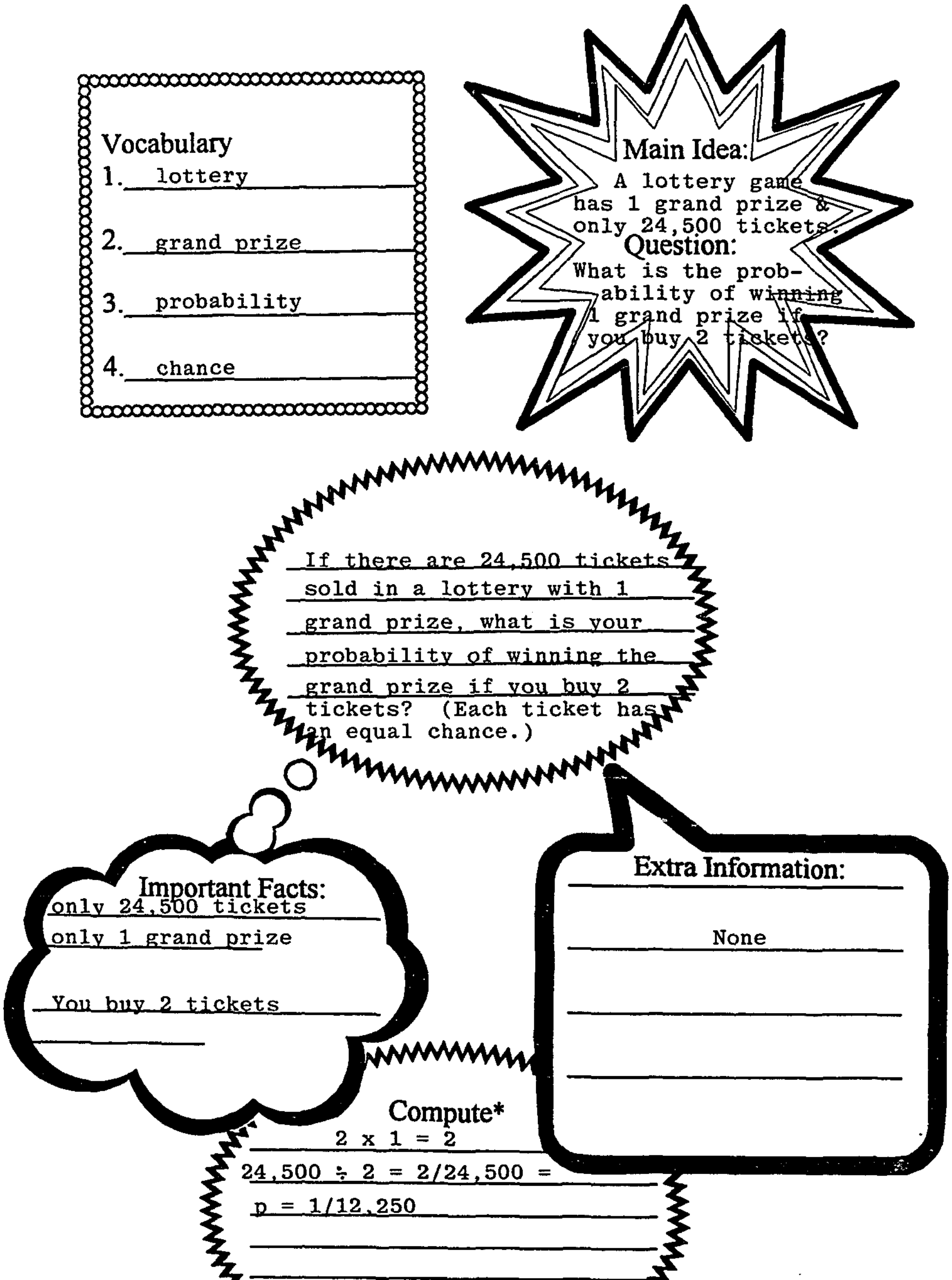
Extra Information:

Compute*

Answer Sentence:____

*Check! Is your answer reasonable? Good Job!

Appendix F
Completed Story Problem Graphic Organizer



Answer Sentence: My probability of winning the grand prize is 1/12,250.

* Check! Is your answer reasonable? Good job!

Appendix G

Sample of Story Problems Used for the Study

1. The Old Stone Age began 2 million years ago. Hunting and gathering began 20,000 B.C. The peak of the Ice Age was about 16,000 B.C. Animals were domesticated in 8000 B.C. Pottery began being made in 7000 B.C. Specialization occurred about 6000 B.C. Which was the earliest? The most recent?

2. The Nile River discharges 18,000 cubic meters of water per second. The Amazon River discharges 15,939 cubic meters of water less than that. How much water does the Amazon River discharge each second?

3. Water covers 139,670,000 square miles of Earth. Land covers 57,270,000 square miles. How many square miles of surface does Earth have?

4. The pharaohs had total power over the lives of their people. They made the laws that the people had to follow. Since the pharaohs owned all of Egypt's land, the people had to pay rent and taxes. If the Egyptians paid an average of $ 275.00 per month in rent, what was the average annual rental cost.

5. Mesopotamian sheep raisers often traded wool fleece for woven wool blankets. One family of 6 traded a flock of sheep for 2 dozen blankets. The blankets had a monetary value of $200.00. If the family shared the blankets equally, how many blankets did each person get?

6. Irrigation in Mesopotamia resulted in a surplus of food production. Farmers sold their produce by the pound. Haikem could buy 6 pounds of fruit for $1.20. How much did Haikem pay for the fruit he bought?

7. The Nile River is 3037 miles longer than the Tigris River. The Tigris River is 550 miles shorter than the Euphrates River. The Euphrates River is 1700 miles long. The Mississippi river is 3,710 miles long. How long is the Nile River?

8. If Catal Huyuk had a population of 1000 in 6000 B.C. and the population doubled every year, what was the population in 6030?

9. An ancient Egyptian trapper started at Memphis and traveled to the Rosetta Mouth, then back to Thebes. If it is 125 miles from Memphis to Rosetta Mouth, and 280 miles from Memphis to Thebes, walking 3 miles per hour, how far did the trapper travel?

Appendix H

Formula for Tukey's Ad Hoc Comparison

$$Q\psi = \frac{|\bar{X}_j - \bar{X}_k|}{\sqrt{MS_{error}/n}}$$

Vita

Born August 22, 1950, Linda Hale Eilers grew up in the Ouachita mountains of Arkansas where she graduated from Mena High School in 1968. After attending Stephen F. Austin State University in Nacogdoches, Texas, she received her Bachelor of Science degree in elementary education from the University of Arkansas at Little Rock in 1973. Linda taught elementary grades in the Little Rock Public Schools from 1973 until 1990.
She earned her Masters of Education degree in elementary education in 1984 and her certification in gifted education in 1989.

After relocating to Monroe, Louisiana, in 1990 Linda began teaching elementary education methods courses to preservice teachers at Northeast Louisiana University. She began her doctoral studies at Louisiana State University in curriculum and instruction, with an emphasis in reading education, in the fall of 1992.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Linda Hale Eilers

Major Field: Curriculum and Instruction

Title of Dissertation: The Effects of Analytic Reading Skills on Sixth Graders' Ability to Solve Mathematical Story Problems

Approved:

Earl Cheek, Jr.

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

J. Neil Mathews

Date of Examination:

March 20, 1996